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Discussions and the request for a copy of a paper should be addressed to the authors at Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan.

CONTENTS

Vibrational Characteristics of Ground Investigated by Several Methods

By Soji YOSHIKAWA, Michiyasu SHIMA and Kojiro IRIKURA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 2, Jan., 1967, pp. 1-16 (in English).

Abstract

The vibrational characteristics of ground were investigated through the observation of natural earthquakes and blasts by means of an oscillator and seismographs being set on the ground surface and in the drift. The ground at the site was composed of three or four layers. When the foundation of the structure is set deep below ground, the amplitudes and the phase difference along the vertical line from the surface will be required and hence it is neceessary to investigate the vibrational characteristics under ground. In view of this fact, seismograms from the ground surface to a depth of 40m were obtained and analyzed. Fourier components were obtained in the case of seismograms of natural earthquakes and blasts, and amplitude-frequency relations for a constant vibrational force in the case of vibrational test by oscillator. The variations in the vertical direction of the amplitude and the phase were obtained at peaks of 4 cps and 8 cps which appeared in the amplitude spectra of the natural earthquakes. It was shown by their distribution that the two apparent predominant periods measured on the ground surface corresponded to two boundaries in the ground structure. It has been made clear that the vibrational characteristics of the surface layer for S waves can be obtained by a blast analysis in which the amplitude ratio between the ground surface and below ground is taken when observation in the borehole is available. The ratios of the amplitude spectra of the surface to those under ground were obtained to allow an examination of the vibration of the spectrum caused by the surface layer. These ratios may be regarded as being related to the vibrational characteristics of the ground only. A similar tendency to that of natural earthquakes may be seen here, though it does not coincide perfectly because the incident condition is rather different and the surface wave is more or less included in the interval of the analysis. The ground structure was rather complicated but amplitude and phase distribution at each measuring point (on the ground surface and in the drift) coincide well with that of theoretical calculations in regard to the ground structure and the spectrum of the place.

Some Problems on Ground Exploration (Continued)

By Soji YOSHIKAWA, Michiyasu SHIMA, Noritoshi GOTO
and Kojiro IRIKURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 165–180 (in Japanese).

Abstarct

The methods of seismic prospecting using SH waves were investigated for ground which contains a thin layer with a high velocity as an intermediate layer or a surface layer. Pickups were installed horizontally on the surface and the three components in boreholes. The method used for the generation of SH waves was to strike a wooden plate pressing down on the ground surface with a hammer in the direction parallel to the plate surface. For the former mediun, the characteristics of interfering head waves in the thin layer and the usefulness of reflected waves from the lower boundary of the thin layer and the floor of the basin were discussed. The head waves had a blunt wave front and wave form of a beat type. The attenuation constants of the head waves were comparatively large, because the wavelength was much larger than the thickness of the thin hard layer, and the arrival distance was short. The reflected waves were recorded three meters in depth and indicated the lower boundary of the thin layer and the floor of the basin, and the depth of their boundaries calculated from the arrival times agreed with that obtained from the borehole data. In the latter, continuous (degenerate) head waves were recorded and used to estimate the velocity of the lower medium. The head waves were that part of the spectrum which was in resonance with the natural oscillations of the medium and were less damped during propagation. The interference effect appeared only in a narrow strip of values of (thickness)/(wavelength). The dominant frequency of this wave was in good agreement with the theoretical value. The propagation velocity was consistent with that of the transverse waves in the underlying medium. The results were consistent with the geological structure of the ground obtained by the borehole observations.

Serismic Prospecting by Three Component Seismographs in a Borehole

By Noritoshi GOTO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 181–188 (in Japanese).

Abstract

To study the velocity profile and the physical property of the superficial layers, seismic explorations using P-wave and S-wave were carried out in the eastern section of Osaka, where paddy-fields and ponds were recentry reclaimed and assimilated into urban development.

It was required to investigate the local characteristics of layered media, consisting of a few discrete layers, from the point of view of the earthquake-proof capacity of unsettled ground, with which the rigidities of near-surface layers are closely connected.

The propagation velocity of the P-wave is studied in ordinary prospecting and the SH-wave is sometimes observed by means of the plate hammering method in refracting exploration. Regarding the refraction method of plate hammering shot, however, it is difficult to catch head waves from deep layers because the SH-wave does not propagate over a long distance by this method. Attempts are made in this paper to separate S-waves on the remainder of the trace recorded from the explosion shot and to develop the method of seismic prospecting based not only on first arrival but also on the later phase of the trace.

Generally it is difficult to separate wave groups on the trace recorded with surface geophones because of the interference of surface waves. So the recordings were made with three component installations of geophones fixed at the bottom of the boreholes, which were respectively 3m, 6m and 25m in depth, and the wave source with small explosion and plate hammering shot were moved on the ground surface between 0m and 55m from the mouth of the hole at 5m intervals. The velocity structure in the region where field experiments were carried out consists of the surface layer and the basic layer. In the surface layer, the velocity of the P-wave is 500 m/s from the ground surface to 2m in depth and 1500 m/s below the level of −2m for water saturation, and the velocity of the S-wave is 90 m/s from the ground surface to 15m in depth. In the basic layer below the level of −15m, the velocity of the S-wave is 380 m/s.

From the observations with the borehole seismographs, some records containing the refracted and reflected SV-waves that radiated from the explosion source were obtained and the travel time of the distinctive phase on the trace was compared with the travel time of the refracted, reflected and converted waves calculated from the velocity profile prospected by the refraction method on the surface and the borehole data.

Vibrational Characteristics of the Ground in the Region of Matsushiro

By Soji Yoshikawa, Michiyasu Shima, Noritoshi Goto and Kojiro Irikura

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 189–199 (in Japanese).

Abstract

Observation of earthquake and seismic prospecting were carried out on the soft ground in the region of Matsushiro in July, 1966. There were 5 observation points, where the ground structures were determined to a depth of 15-20 meters using SH waves as well as P waves.

During the period several earthquakes of intensity 1-2 were observed at each site. The main phases of observed seismograms were read and Fourier-analyzed with the purpose of investigating the vibrational characteristics of the soft ground.

The P-S times of observed earthquakes range from 1 to 2 seconds and the main phases are contained in the S wave parts. The predominant frequencies range from 1 to 10 cps. The peaks of the spectra in the 4-10 cps coincide approximately with the fundamental mode of the theoretical curves computed by the multiple reflection theory of SH waves. It is difficult to discuss the peaks appeared at less than 4 cps because the distribution of S waves at layers deeper than 20 meters was not clarified by the results of our seismic prospecting. We could not distinguish whether the peaks were due to the sources and the paths, or to the surface layers. The spectra decrease rapidly at more than 10 cps and the peaks of higher mode are not clear. This seems to be caused by wave-dampings due to visco-elasticity of superficial layers. We have not yet been able to measure attenuation coefficients of S waves in field experiments.

The results of S wave prospecting were somewhat different from those of P wave prospecting. In our experiments, the ground structure obtained by S wave prospecting was found to be closely correlated with the spectral structure of the main phases.

Some Properties of Microearthquakes in the Vicinity of the Neo Valley Fault, Central Honshu, Japan

By Hikaru WATANABE and Masao NAKAMURA

ZISIN, Ser. 2, Vol. 20, No. 2, June, 1967, pp. 106–115 (in Japanese).

Abstract

Using the data obtained from the co-operative observations of microearthquakes in 1963 and 1964, some properties of microearthquakes in the vicinity of the Neo valley Fault were investigated in comparison with large earthquakes occurring within the past 70 years in the area concerned.

As a result, we could find that the seismic activity of the microearthquakes was closely related to the earthquake fault on a large scale, though the foci of microearthquakes were not always distributed uniformly over the fault zone. Many shocks occurred on the southwest side of the fault and they uniformly decreased with distance from the fault. In the northeast side of the fault, however, there was an aseismic area where no shock occurred. Moreover, it is noteworthy that large earthquakes which have occurred since the outbreak of the Mino-Owari Earthquake in 1891 were also distributed in exactly the same manner.

According to these facts, it has become apparent that the seismic activity of microearthquakes may well represent the seismicity of the past on a somewhat greater scale. From this point of view, the generation mechanism of the earthquake fault was briefly considered in connection with the manner of seismic activity in the vicinity of the Neo Valley Fault, though it was too early to discuss such a problem in more detail.

Some Properties of Microearthquakes in the west of the Kii Peninsula, Central Honshu, Japan

By Hikaru WATANABE and Akio KUROISO

ZISIN Ser. 2, Vol. 20, No. 3, Sept., 1967, pp. 180–191 (in Japanese).

Abstract

In August 1965, co-operative observations of microearthquakes were made by the Research Group for Ultra-microearthquakes at 10 temporary stations and also at 12 permanent stations of the Earthquake Research Institute of the University of Tokyo, spread widely over the Wakayama District, Central Japan. The seismographs and the method of observation were almost the same as we had used in the previous co-operative observations in the Gifu and Fukui Districts.

As a result of the observations, we could confirm that the area concerned was divided into several seismic active regions according to the spatial distribution of foci of the microearthquakes. Besides the problem of seismicity, several properties regarding the generation mechanism of local earthquakes, the earthquake sequence and the anomaly in travel time curve were studied in some detail in comparison with the previous results obtained by many authors in the area concerned.

On Seismic Waves Generated by Small Explosions

By Akira KUBOTERA and Yutaka OHTA

Special Contributions of the Geophysical Institute, Kyoto University,
No, 6, Dec., 1966, pp. 267-279 (in English).

Abstract

The problem related to seismic waves generated by small dynamite charged explosions has been investigated based upon the experiment carried out by the Exploration Group of Japan at Shirane City, Niigata Pref. in 1965.

There are four different types of wave groups; namely, wave groups I, II, III and IV. Comparative investigations of wave groups III and IV have been made both theoretically and experimentally by several authors.

Consequently, in the present paper, characteristics of wave groups I and II are mainly treated.

Wave group I is concluded to be composed of various kinds of converted waves generated from the interfaces under the surface. While, in wave group II, three different kinds of waves are found; a kind of surface wave having the longest wave length among the wave groups, a wavelet of direct P wave and refracted SV waves. Of these three kinds of waves, the main part of wave group II of a surface wave type is more interesting. Its wave form and characters are equivalent for the normal mode wave in the liquid-liquid layers. Namely, its phase velocity lies between the propagation velocities of the P waves in the surface layer and half space, its amplitude distribution in depth shows the same form as the surface wave having a loop on the surface and one node in the layer.

Moreover, Poisson's ratio in our experimental field is almost 0.5, so it closely resembles the liquid state. Therefore, it is quite possible that among the wave groups generated by expiosions, there is a suface wave of a type similar to the normal mode wave in liquid-liquid layers.

Focal Mechanism of Volcanic Earthquake of the Volcano Aso

By Tatsuhiko WADA and Yasuaki SUDO

Bulletin of the Volcanological Society of Japan Series II, Vol. 12,
No. 2, August, 1967, pp. 61-69 (in Japanese).

Abstract

From the summer of 1965 the Volcano Aso became active and the most violent eruption happened on October 31, 1965, the energy of which amounted to 10^{18} erg, with a great deal of ash and fragments of rock and fresh lava. The volcanic earthquakes were observed at the Hondo observation room of Kyoto University. By analysing the data, the focal mechanism and the distribution of volcanic earthquakes will be discussed. The sign of the initial phase of earthquake wave (push or pull) plays an important role in the study of the focal mechanism. In volcanic earthquakes, however, such a study is infrequent because of unsatisfactory observatons and the inherent ambiguity of the initial phase. Fortunately, in the case of the Volcano Aso, an interesting investigation during the prominently active period, that is, from 1932 to 1933, was reported by Sassa (1936). We can re-examine the seismicity and the focal mechanism in comparison with the results given by Sassa. The main results are as follows: (1) During the earlier period (or before the eruption sequence), the foci gather in a particular region, and during the later period they are scattered. The focal depths are between about 500 and 1,000 meters below the bottom of the crater; (2) The existence of earthquakes of the rarefaction type, that is, the initial phases are all pull around the epicenter, is found. Earthquakes of this type frequently occurred in the earlier period, but rarely in the later period. The ratio between the number of the earthquakes possessing the initial phase of push and the number of the earthquakes possessing the initial phase of pull varies in the present case in the same way as in 1932-33, and such a fact is thought to be essentially derived from the variation of the focal mechanism, and could be at least partly related to the existence of the rarefaction type; (3) The particular region occupied by foci occurring before the eruption sequence could be closely related to the direction in which the ejected materials are thrown out during the main eruption, as if the region were the pressure origin. These results are also interesting for the study of forecasting the eruption of a volcano and therefore more precise observation is necessary. The study of earthquakes of the rarefaction type will be especially significant because of the relation with the mechanism of volcanic activity.

Volcanic Crustal Deformations (III)
···Crustal Deformations in the Vicinity of Aira Caldera and the Activity of Volcano Sakura-jima···

By Tsuneo ETO

Bulletin of the Volcanological Society of Japan, Series II, Vol. 12
No. 2, August, 1967, pp. 80–88 (in Japanese).

Abstract

The vertical deformations of the earth's crust in the vicinity of Aira Caldera were studied from the results of precise levelling surveys and observations of the sea level by means of tide gauges.

Relative vertical deformations of Sakura-jima Volcano in recent years were obtained from the continuous observation data of the mean sea level between Kagoshima and Hakamagoshi. Upheaval movements of Sakura-jima Volcano were also revealed from the results of precise levelling surveys around Kagoshima Bay made in 1960 and repeated in 1962. Those two results were not so different from the amount of vertical displacements between Kagoshima and Sakura-jima Volcano.

The great Sakura-jima eruption in 1914 was followed by abnormal changes in the height of the mean sea level of Kagoshima Bay. In recent years, the relative elevation of B.M. 2474 has been recorvering and becoming as high as it had been in 1891 before the great eruptions in 1914. These facts may suggest the gradual accumulation of powerful volcanic tension under the center of Aira Caldera.

Tidal Analysis by the Fourier Transform Method

By Torao TANAKA, Ichiro NAKAGAWA and Takeshi MIKUMO

Journal of the Geodetic Society of Japan, Vol. 12, 1966, pp. 77–84, (in Japanese).

Abstract

Tidal analysis has been made by the Fourier transform method for the gravimetric and tiltmetric records of one year duration, observed at Kyoto and Wakayama respectively, to obtain the spectral structure of the earth tides and some related phenomena.

The obtained spectral peaks for the semidiurnal and diurnal tides are in excellent agreement with theoretical prediction. The amplitude and phase of 8 principal constituents, M_2, S_2, N_2, K_2, K_1, O_1, Q_1, and P_1 have been determined for their proper periods, and compared with those from the method of least squares. The comparison shows satisfactory agreement.

Spectral features for longer period ranges up to one month are also investigated. Several prominent peaks with periods of 11.1, 11.9, 16.2 and 18.5 days, as well as for the fortnightly constituents Mf (13.66 days) and MSf (14.77 days), are detected. The sources of the long-period variations are not yet precisely known, but the analysis is under way for observed records of temperature and atmospheric pressure and oceanic tides.

On the Method of Hypocenter Determination of Microearthquakes

By Michio HASHIZUME and Yoshimichi KISHIMOTO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 35-41 (in Japanese).

Abstract

A method of determining the hypocenter of microearthquakes was described using the data at the Tottori Microearthquake Observatory. First, poisson's ratio of the crustal material in the north-western Kinki District was studied and estimated as 0.2435 ± 0.0015. The deviation of the observed points from the line of $\sigma=0.2435$ is considered to be, in some cases, caused by various real origins, such as the differences in Poisson's ratio with region and depth.

One of the most fundamental points is considered the identification of the S phase when we determine the hypocenter by any method using the S phase. In the present analysis, the S phase was so identified as to fit the above-estimated Poisson's ratio, using only very good seismograms in which the time accuracy of P arrival is less than 0.1 sec. This criterion seems reasonable from the fact that the S phase was so clearly and reasonably identified in many records. Origin time was determined by the method of least spuares, giving P travel times. The hypocenter was determined graphically by use of these observed P travel times and the crustal structure obtained by the Kurayoshi-Hanabusa explosions. It is a three-layered crust with its 1st layer of 5.5 km/sec. of P velocity and 3 km thickness, its 2 nd layer of 6.05 km/sec. and 13 km, and its 3 rd layer of 6.6 km/sec and 20 km. The results were fairly satisfactory. Concerning the epicenter, about 95 % of the earthquakes used were determined within an accuracy of $\pm$ 1.0 km, but the determination of focal depth was less satisfactory compared with the epicenter. P travel time curves of earthquakes of which focal depth was well determined were compared with the theoretical ones. The observed travel time curves in three ranges of focal depth, 3-7 km, 8-10 km and 11-14 km, were compared with theoretical curves of 7, 10 and 13 km, respectively. These comparisons seem, in general, to show fairly good agreement between the observed data and theoretical curves, suggesting that both the method used here and the assumed structure are satisfactory as a first approximation.

On some Properties of the Matsushiro Earthquake Swarm

By Yoshimichi KISHIMOTO, Kazuo OIKE and Kazuo MINO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 43-50 (in Japanese).

Abstract

A relationship between the magnitude of earthquakes and the frequency of occurrence, the so-called Ishimoto-Iida relation, was examined in the case of the Matsushiro Earthquake Swarm. The observation was continued for about three months from June to September, 1966 at Sanada Town.

The seismograph system was as follows ; 1c/s moving-coil transducer, electronic amplifier and 30 c/s ink-writing galvanometer. Each earthquake was recorded simultaneously at four ranges of sensitivity in order to cover fairly wide ranges of magnitude. Sensitivities of these four ranges and other things are as follows ;

Range	Sensitivity	Number of observed eartnquakes per 8 hours	Range of observable magnitude
1	0.32 mkine/cm	1500 ca.	$-1 \sim 0$
2	1.6	500	$0 \sim 1$
3	8.0	100	$1 \sim 1.5$
4	40	20	$1.5 \sim 2$

The Ishimoto-Iida relation seems to somewhat change its form and also the value of m. Roughly speaking, the form of the Ishimoto-Iida relation seems to be classfied into three modes, if it is represented by a both-log diagram, namely, in a joint range of range 2 and 3,

1) one simple straight line, 2) two straight lines intersecting at a certain amplitude, and 3) a pretty complicated shape with a few branches. These variations of the form of the Ishimoto-Iida relation may probably be related to the seismic activity in the neighbouring area.

The mechanism of occurrence of microearthquake was studied, using the data of high-accuracy observation by tape-recording system carried out during a period of from Dec. 20 to 25, 1965. The data used were 30 earthquakes observed at three stations, Shinkô, Mure and Soehi which were all at nearly the same distance from Matsushiro. The mechanisms of these earthquakes were approximately represented by the so-called four-quadrant type in which the principal stress nearly lies in an east-west and horizontal direction. But this direction seems to vary in the horizontal plane, and the maximum difference between them was estimated as about 30°. This change of direction of the principal stress may have some relation to the earthquake magnitude.

Report on the International Cooperative Observations of the Crustal Movements Related to Seismic Activities (Preliminary Report)

By Research Section of Crustal Movement

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 77-111 (in Japanese).

Abstract

For the purpose of carrying out research into the relations between crustal movements and seismic activities and finding some clues for earthquake prediction, international cooperative observations of crustal movements were planned by the three countries of Japan, Peru and Chile.

Eight of the thirteen observation stations are distributed in Peru and five in Chile, and the observations in Peru and Chile were commenced at the end of 1965 and the beginning of 1966 respectively.

In this preliminary report, the significance of the observations, the process from plan to practice of the observations, the main contents of agreement on the cooperative work, the location and condition of the observation stations, the equipment and methods of the observations and the like are described in some detail.

The locatins of the observation stations and the responsible organs under the agreement are given in the accompanying table. The type and number of observation instrumemts are iust the same at all stations and those for one station are as in the following:

Extensometer of bow-string type	2 components
Tiltmeter of horizontal pendulum type	2 components
Variometer of geomagnetic declination	1 set
Variometer of temperature and pressure	1 set
Photographic recorder	2 sets

The recording papers are replaced once a week and clear duplicates of observed records in their original size are sent to Kyoto University. The agreement is effective for ten years from 1965 and will be further extended for a specified period by mutual consent.

Country	Responsible organ	Observation station	Longitude W° ′ ″	Latitude S° ′ ″	Height m
PERU	Instituto Geofisico del Perú, Ministerio de Fomento y Obras Publicas, Lima	*Ica region*			
		Condor	75 32 00	13 32 55	1550
		Guadalupe	75 47 30	14 00 15	550
		Saramarca	75 06 00	14 30 20	840
		Zamaca	75 36 45	14 40 20	300
	Instituto Geofisico, Facultad de Ciencias, Universidad Nacional de San Agustin, Arequipa	*Arequipa region*			
		Arequipa	71 33 43	16 26 34	2300
		Ayanquera	71 40 19	17 00 47	250
		Ongoro	72 28 30	15 53 57	900
		San Gregorio	72 42 45	16 33 52	140
CHILE	Departamento de Geofisica y Geodesia, Facultad de Ciencias Fisicas y Matematicas Universidad de Chile Santiago	*Santiago region*			
		Queltehues	70 13.6	33 49.0	1800
		Polcura	71 30.7	37 18.3	753
		Rapel	71 45.2	33 57.4	95
		Concepción	73 02.7	36 49.0	10
		Tololo	70 48.9	30 11.8	1400

Preliminary Report of the Kamitakara Crustal Movement Observatory

By Tokio ICHINOHE and Susumu TOMINAGA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 113-121 (in Japanese).

Abstract

The Kamitakara Crustal Movement Observatory was established on April lst, 1965, for the purpose of investigating the relations between crustal movement and earthquake occurrence and finding some clues for earthquake prediction. Although some kinds of observations commenced in July 1966 at this observatory, it is still premature to report the results. In this report, therefore, the features of the observatory, kinds of observations carried out at present, main equipments and the like are described.

The observatory consists of three parts; the main building, observation dome, and observation tunnel, the first two of which were completed in November 1965 and the later in March 1966. The observatory is situated in Kamitakara Village, Yoshiki-gun, Gifu Prefecture, the location of which is as follows:

Observation dome: $\lambda=137°21'57''$E, $\varphi=36°17'20''$N, h=600 m,
Observation tunnel: $\lambda=137°19'42''$E, $\varphi=36°16'54''$N, h=800 m.

The main subjects of observations and investigations being carried out in this observatory are as follows:

(1) Measurements of crustal movements by means of geodetic methods,
(2) Continuous observations of crustal movements by means of extensometers, tiltmeters and the like,
(3) Observations of seismic activities by means of various seismographs,
(4) Adjustment and analysis of the observation data on crustal movements,
(5) Synthetic investigation of the methods for earthquake prediction.

The main instruments installed in the observation tunnel and their sensitivity are as follows:

Name of the instruments	Sensitivity	Components	Recording
Fused silica extensometer	28 m, 7×10^{-9}/mm	3	Optical
Horizontal pendulum tiltmeter	0.005''/mm	2	Optical
Water-tube tiltmeter	30 m, 0.0067''/μ	2	Reading
Long period seismograph of Press-Ewing type	$T_1=20$ sec, $T_2=100$ sec $h_1=2.0$, $h_2=0.7$ $V_{max}=1000$	3	Optical

Crustal Movements related to the Seismic Activity in Restricted Area (1) —Relation between the Seismic Activity in the Outer Zone of the Tohoku District and the Tilting Movements Observed at the Hosokura Station—

By Yutaka TANAKA, Masaaki KATO and Makoto KOIZUMI

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 123-140 (in Japanese).

Abstract

The present paper is a general report on the long term observation of crustal movements at the Hosokura station in the Tōhoku District, and further, the first of a series of papers in which the relation between the seismic activities and crustal movements in some restricted areas will be reported.

Observation results by means of tiltmeters support the following view.

(1) The relation between the mode of crustal movements for the long wave length and the activity of shallow earthquake sequences in the outer zone of the Tōhoku District.

The mean velocity of the tilting motion of the ground at Hosokura, as far as the E-W direction is concerned, changes coincidentally with the alternations of sequence of shallow earthquakes which occurred in the region of Sanrikuoki (off the eastern coast of the district), and elastic deformations as shown by the see-saw motion are superimposed on these stepwise motions of secular ground tilt, decreasing its amplitude and shortening its period with time. Earthquake swarms occur near the peaks of the curve showing the see-saw motion. These modes of crustal movements at Hosokura are essentially similar to those of the Makimine station related to the seismic activities in the sea area of Hyūganada.

(2) Attention is drawn to the elastic deformation caused by a series of very shallow earthquakes which originated near Hosokura, in the northern part of Miyagi Prefecture.

Two medium earthquakes seemed to belong to the same sequence of earthqukes which occurred at almost the same position, at 25 kilometers' distance from Hosokura to the south-east, on Aug. 11, 1963 and Jan. 13, 1965. Their magnitudes are 5.3 and 5.2 respectively. The modes of crustal deformation directly related to the respective earthquakes are entirely different from each other. It seems that each earthquake occurred under a different state of ground strain, which is inferred from the curve of strain energy release in the sequence. It may be suggested that crustal deformations related to a sequence of earthquakes are not always a simple superimposition of typical deformation caused by an individual earthquake, but earthquakes in the sequence only occur, according to the progress of strain, at some climaxes of a series of crustal movements.

Seismometric Observations of Matsushiro Swarm Earthquakes

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 17, Part 1, July, 1967, pp. 9–26 (in English).

Abstract

Part I. Continuous Observations

By Yoshimichi KISHIMOTO, Michio HASHIZUME, Kazuo OIKE, Kazuo MINO,
Tsuneto KURITA, Ryohei NISHIDA, Kunihiko WATANABE
and Shigemitsu MATSUO

Continuous observation by a short-period and high-sensitivity seismograph system has been carried out at Shinko Village since December, 1965, for the purpose of investigating the time variation of seismic activity. Time variation of the daily number of earthquakes and S-P time distribution were described for about 7 months from June, 1966 to January, 1967. Another observation at Sanada Town was mentioned, which had the special purpose of investigating the Ishimoto-Iida's m. The observation was made in 4 different ranges of magnification to cover a wide range of magnitude.

Part II. Magnitudes of Matsushiro Swarm Earthquakes

By Haruo MIKI, Kennosuke OKANO, Isamu HIRANO, Shozo KIMURA,
Yasuhiro UMEDA and Hiroshi WATANABE

For studying the attenuation of seismic waves in short hypocental distances and the magnitude of the Matsushiro swarm earthquakes, four observation points equipped with low magnification seismographs of the displacement type were installed on the lines from Matsushiro to Komoro and Matsushiro to Toyoshina through Akashina. The attenuation coefficient was estimated as 0.067 from 25 earthquakes. Magnitudes of about 150 weak shocks were determined to be from 0.8 to 3.0 from an empirical formula showing the relation between maximum trace amplitudes and S-P times.

Part III. Mobile Observations of Ultramicro-earthquakes

By Haruo MIKI, Hikaru WATANABE, Masao NAKAMURA, Akio KUROISO,
Shozo KIMURA; Yoshimichi KISHIMOTO, Michio HASHIZUME,
Kazuo MINO and Shigemitsu MATSUO

Mobile observations were carried out three times from June to November, 1966, for the purpose of surveying seismic activity outside the seismic region of the Matsushiro swarm earthquakes. The observation system, which records only the frequency distribution of S-P times, proved useful for a quick understanding of seismicity and its variation in time and space, in regions where a dense network has not yet been established.

Part IV. Observation of Microearthquakes around Mt. Minakami

By Hikaru WATANABE, Masao NAKAMURA, Akio KUROISO, Junpei AKAMATSU; Takeshi MIKUMO, Kazuo OIKE and Kunihiko WATANABE

Temporary observation of microearthquakes was carriet out at three recording sites with a span of about 3 km around Mt. Minakami, to examine if a possible correlation existed between the spatial distribution of the earthquakes and local ground cracks in the area. Epicenters of 255 shocks were located by the use of S-P times. Most of them concentrated on the northeast side of the cracks, and no shock was found under or just around Mt. Minakami.

Continuous Observations of the Ground Deformations Related to the Matsushiro Earthquakes

By Tokio ICHINOHE, Michio TAKADA, Torao TANAKA, Tamotsu FURUSAWA, Masaaki KATO, Makoto KOIZUMI and Masaru YAMADA

Bulletin of the Disaster Prevention Research Institute, Kyoto University, Vol. 17, Part 1, July, 1967, pp. 49-61 (in English).

Abstract

In order to investigate the relations between ground deformations and seismic activities in Matsushiro and neighbouring regions, continuous observations of the ground tilt and strain were carried out at Matsushiro and Suzaka.

At Matsushiro, three tiltmeters of the horizontal pendulum type and two extensometers of the bow-string type were installed in the underground gallery bored into Zōzan hill, in the western suburbs of Matsushiro Town. At Suzaka, two tiltmeters of the water tube type and two tiltmeters of the horizontal pendulum type were installed in the underground gallery bored halfway up Kamatayama hill, in the eastern suburbs of Suzaka City.

At Matsushiro, the observation was continued from Dec. 23, 1965, until Mar.23, 1966. In this period, several earthquakes of a magnitude larger than 4.0 occurred, and peculiar tilting movements of the ground were detected before and after the earthquakes at 22 h 34 m on Jan. 8, 1966 (M=4.7), and at 07 h 03m on Mar. 10, 1966 (M=4.4), the epicentral distances of which did not exceed 1 km. The mode of the movements bears a striking resemblance to that reported in respect of the occurrence of earthquakes in other regions. Additionally, the velocity increase of the northward tilting was observed at Matsushiro when the seismic activity was high in this observation period.

At Suzaka, the observation has been carried out since July 22, 1966, till the present, and it proved that the direction of the ground tilt changed markedly every time an earthquake of a magnitude larger than 5.0 occurred, and an anomalous ground tilt appeared before the occurrence of the earthquakes at 04 h 03 m on Sep. 27, 1966 (M=4.6), and at 18 h 49 m on Feb. 8, 1967 (M=4.2). A common phenomenon in the cases of these two earthquakes is that the ground tilt reversed the direction of its movement at the time a foreshock occurred. This observational fact seems to indicate that the deformation of the earth's crust reversed the direction of the process at the time the forerunning fractures of rocks at the focal region commenced. If such behaviour of the crustal deformation were common to all earthquakes, it will be very useful for earthquake prediction. But according to past observation results it is not always so. More observation examples are needed before drawing any conclusions about this problem and predicting the occurrene of earthquakes.

On Landslides in Southeast Asia

By Shinichi YAMAGUCHI

Journal of the Landslide Society of Japan, No. 8, Feb., 1967, pp. 7–16 (in Japanese).

Abstract

When we explain the cause of a landslide, we are used to doing it from two sides. The first one is from inducing factors, for example, melting of accumlated snow, rainfall, variation of ground water level, change of ground-water way, earthquake, leaching action etc.. The second one is from basic factors, for example, Tetiary zone, fractured zone, volcanic action zone, clay zone acted by hot spring, mariene clay zone etc.. Moreover, we sometimes explain from the geographical side.

But these explanation styles are only based upon a qualitative, and not quantitative view point. We cannot estimate what percentage of the cause of a landslide will be occupied by basic factors or inducing factors. Nor can we presume what percentage of the cause is occupied by one pecular inducing factor when there are many inducing factors. Does the landslide always occur when there is the same combinaton of inducing factors and basic ones? Or, at least, can we estimate the percentage of occurrence at any combination of inducing factors and basic ones? These problems mentioned above have not been made clear up to the present time. It may be one way to carry out geophysically precise observations on numerous landslides and make clear the mechanisms of occurrence of those landslides and make statistics of major factors. Or it may be considered as another way to investigate the relation between inducing factors and basic ones at landslides in entirely different climatic regions from Japan.

We planned to investigate the distribution and character of landslides in Southeast Asia according to the above mentioned idea.

There run two famous tectonic lines in Southeast Asia. One is the Thesis tectonic line which runs from northern Italy to Java, through Nepal. And another one is the circum-Pacific tectonic line which runs from Japan to the Phillipines, through Formosa. There are many volcanoes and hot springs along tectonic lines, containing the Tertiary. Accordingly we can compare landslides in Southeast Asia with those in Japan covering three types, namely, fractured zone type, hot spring type and Tertiary type. This is the report of the preliminary research on landslides in Southeast Asia.

Some Characteristics of the Kamiōgi Landslide Area

By Shinichi YAMAGUCHI, Yuji TAKADA, Atsuo TAKEUCHI
and Takahiko FURUYA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 467–477 (in Japanese).

Abstract

The Kamiōgi landslide area which consists of the Paleo-Biwa group, is located in the middle part of the Shiga hills along the west coast of Lake Biwa. This landslide area is composed of numerous small landslides. The topography of the Kamiōgi landslide area and its environs is hill morphology, and it is a well preserved flat surface which seems to be a lacustrine terrace surface. The phenomena of landslides are limited to the southern part of the slope of this hill morphology, from 150 m to 240 m in height.

In order to clarity the geological, geomorphological and hydrological factors of these landslides, investigations of the internal strain, a geological and geomorphological survey, and a ground water survey, including electric survey, were performed on the Kamiōgi landslide area. Briefely the results of the survey indicate that the landslide characteristics of the Kamiōgi landslide area are as follows:

(1) The Kamiōgi landslide area consists of small slope ruptures continuing for a long time, and looks like the failure of brittle materials.

(2) The slope ruptures occurred at a height of approximately 190 m, at the boundary between the siltstone layer of the bedrock and its covered gravel layers. The siltstone layer is composed of consolidated and compact materials, and the gravel layer is composed of unconsolidated and loose materials. The former layer is Minamisho formation and the later layer is Kamiōgi gravel layer which is predominantly granite boulders and gravels,strongly affected by the red-soil formation.

(3) Those slope ruptures were related with the water from the gravel layers.

(4) The location of the slope rupture is situated on the changing portion of the slope.

(5) The occurrence of the slope rupture is mainly during heavy rainfall, and especially abounds in the typhoon season.

On the Matsushiro Landslides

By Shinichi YAMAGUCHI, Setsuo OKUDA, Yasushi KITANO, Yuji TAKADA, Kazuo OKUNISHI, Atsuo TAKEUCHI, Takahiko FURUYA and Ryuma YOSHIOKA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 479-490 (in Japanese).

Abstract

The Makiuchi landslide and the Gotenyama landslide occurred at Matsushiro town, Nagano city on Sept. 17 and Oct. 9, 1966 respectively. These areas where the landslides occurred are situated in the middle of the Matsushiro earthquake swarm which induced the faults, cracks, spring discharges and upheaval of crustal block. These landslides belong to a very rare type, therefore natural radioactivity survey and chemical analysis were carried out to explain the mechanisms of the occurrence of these landslides.

Natural radioactivity near cracks and faults ranging from 2.5×10^{-3} mr/h to 6.2×10^{-3} mr/h, implis the existence of active faults and hot spring activity. Futhermore we continue this survey to estimate whether the faults and cracks and hot spring activity are increasing or not by the observation of the natural radioactivity variations.

Chemical analysis of the water samples collected from the springs which gushed out after the landslides, was carried out in order to estimate the origin of the water and study the mechanism of gushing out.

Successive changes in water temperature, pH, concentrations of Na^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-}, and soluble SiO_2 were investigated from periodical samplings in the landslide regions. The general conclusions to be drawn from the analysis are as follows.

(1) Increase of water temperature irrespective of air temperature and high concentrations of all ions suggest the origin of the water in great depth.

(2) Different constitution of chemical elements in different regions suggests the possibility of distinction of undergound water systems by chemical analysis.

(3) Prompt increase in the ion concentrations from September to October 1966 and relative increase in Ca^{2+}, Cl^-, in other ions are the most notable phenomena in the water from the landslid regions.

(4) Hydrological investigation, especially of the water balance in the basins, must be carried out simultaneously for exact study of underground water systems.

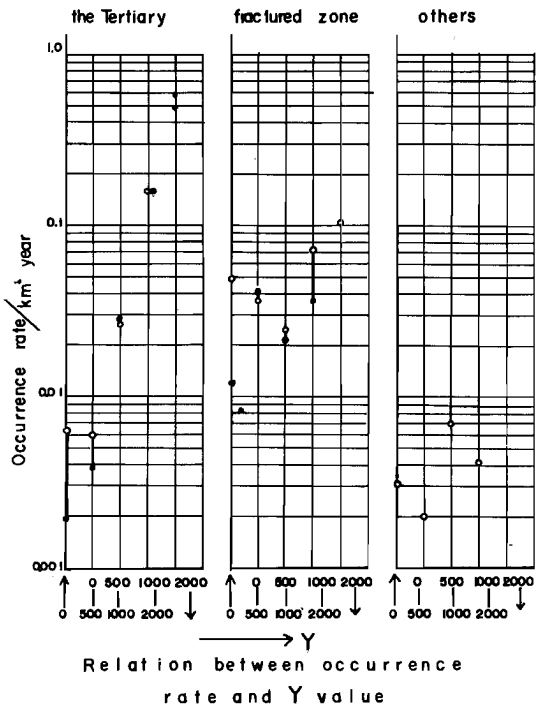
On the Basic Factors and Inducing Factors of Landslide

By Shinichi YAMAGUCHI

Journal of the Landslide Society of Japan, No. 10, August, 1967, pp. 4-11 (in Japanese).

Abstract

We consider certain factors as the causes of landslides. These factors are classified into two groups. One group indicates the weakness of ground from a geological viewpoint, and is called a basic facor. Another group indicates the direct cause of landslides and is called a basic factor. Commonly, the mutual actions of those factors which belong to both groups are considered as the cause of landslides.



Relation between occurrence rate and Y value

We found the following laws as the results of a study of these mutual actions. The occurrence rate per unit area in the Tertiary region has a close straight correlation with Y value, which means the amount of rainfall minus evaporation per one year at the place. The occurrence rate in the fractured zone is considerable, but has nothing to do with the Y value. The occurrence rate in the region which does not belong either to the Tertiary or the fractured zone, is very low and has nothing to do with the Y value.

The occurrence rate of landslides in the Southeast Asia, Formosa and Korea region, where the basic factors are common to those in Japan but where the boundary condition of inducing factors is more extensive than is Japan, are estimated from the above mentioned laws and it is confirmed that it coincides with the actual circumstances.

Preliminary Report on the Crushing Type Landslide

By Takahiko FURUYA

Landslide, Vol. 4, No. 2, Dec., 1967, pp. 21-31 (in Japanese).

Abstract

In Japan, excluding the volcanic region, a great many active landslide areas coincide with the distribution of the Tertiary formations, faulted and fractured zones and metamorphic belts.

These landslide areas are in general divided geologcally into the Tertiary type and Crushing type. Tertiary type landslides are mostly connected with mountainland. Accordingly, in landslide area sgeological and geomorphological studies are extremely important.

From this point of view, the writer applied techniques of geomorphology in the bistribution of the Crushing type landslide which was shown in the topographical map of Kawaguchi 1:50,0000. The results of this investigation are summa rized as follows;

1) Distribution of landslide areas convergs on the rivers Yoshino Iya and Matsuo Distributed pattern of these landslide areas is arranged in an east-west, line, and this pattern coincides with the direction of liniation.

2) The landslide areas abound on the fringe of the residual erosion surface.

3) The localities of this landslide area abound of height of 500m and 800m and these heights are concerned with the base level of erosion.

4) The inclinations of the landslide areas are about 25 in general. This inclination is higher than Tertiary type landslide areas of the Oboke formation and Mikabu-greenrocks are not concentrated near 25. This fact is different from other formations of the investigated area.

5) Relief of the investigated area is 800m of its maximum height, and the landslide area exists mostly of from 300m to 600m in relief heights.

6) The geology of the landslide areas consists of the metamorphic rocks and weakly metamorphosed rocks of the paloeozoic formations. The localities of the landslide areas abound chiefly in the crystalline schist of the Minawa formation,koboke formation and Kawaguchi formation of the Sambagawa metamorphic belts, and only a little in the weakly metamorphosed rocks, so-called Mikabu-greenrocks, which are composed of meta-gablo, meta-diabase, basalt, and basaltic agglomerate.

The genesis of landslides receives a hint from these facts, namely, the physico-chemical nature of rocks.

7) The landslide areas having closed on he fault line which is shown in the geological maps of sheet Kochi-42 are little 20 percent.

Some Experiments on the Sedimentation in Estuaries with Density Stratification

By Seiichi KANARI

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, Dec., 1966, pp. 127-133 (in English).

Abstract

For the study of coloid chemical and hydrodynamic effects on estuarine sedimentation, the settling processes in a salt wedge were investigated by flume experiments. The experiments were carried out in a flume which consisted of a sea section (3 m × 3 m × 0.5 m) and a river section (7 m × 0.5 m × 0.5 m). Silicious sand of about 0.3 cm uniform dia. was placed along the floor of the river section with a slope of 12/6. Salt water, which was a solution containing Na^+, Cl^-, Mg^{++} and SO_4^{--} with a ratio similiar to sea water and was coloured with Fuchsin, was stored in the form of a wedge on the slope of the flume, and then fresh water was allowed to flow onto it without disturbing the salt wedge. In each experiment, some combinations of the fresh water discharge, Q and the salinity of the salt wedge, S were selected from Q=2.5m³/h, 5.0 m³/h, 7.5 m³/h and S=0‰, 17.5‰, 35.0‰, After the flow of the fresh water and the intrusion of salt wedge were maintained at the given position, turbid water with a silt concentration of 30g/l was poured at a flow rate of 0.25 m³/h into the rectifying tank, therein mixed with fresh water and then allowed to flow into the river section. The turbid water inflow continued for 7 minutes at an almost constant discharge rate. During each experiment the fresh water level was kept constant by the overflow.

Water sampling from the three layers (upper, medium and lower) was carried out at the four sections by means of the siphon method each minute after the front of the turbid water had passed on, and silt concentrations of each sample were measured by weighing.

In most cases, the bulk of the sediment in real estuaries or mouths of rivers consists of silt particles transported by floods. Under such conditions, it had been supposed that the settling processes of suspended silt particles would be directly influenced by coloid chemical conditions. However, the flume experiments showed that a strong turbulence existing in a highly concentrated mud flow which may arise during a flood, controls the silt distribution, and it seems that the chemical effects do not play a dominant role in sedimentation in the estuaries with sharp density stratification because their stable interface prevents the contact of cations with solid particles.

Salt Balance in Lake Kojima

By Setsuo OKUDA

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, Dec., 1966, pp. 135-145 (in English).

Abstract

It is necessary for the effective utilization of water from estuarine reservoirs to investigate the salt balance and salinity distribution in the reservoirs.

As an example of the surveys on estuarine reservoirs, the results of the observation in Lake Kojima over ten years after the closing of the bay mouth were analysed on the basis of experimental and theoretical studies of salt transport, in order to calculate the incoming and outgoing items of salt balance.

A balance sheet table for salt in Lake Kojima during the exact survey period from June 12-July 30, 1964 is shown as follows.

incoming of salt		
(i) sea water intrusion through gates and bank		76.0×10^3 tons
(ii) brackish water from polder land		9.2×10^3
(iii) sea water through lock gates		2.3×10^3
(iv) salt from bottom soil		0.9×10^3
	total	88.4×10^3 tons
outgoing of salt		
outflow through gates in the drainage period		177.0×10^3 tons
amount of salt stored in the lake		-88.6×10^3 tons

The amount of stored salt for the same period can be estimated from the difference of salinity distribution in the lake before and after the period, independently of the above mentioned balance method,

The amount was estimated as -91.3×10^3 tons by the latter method and shows a good agreement with the value obtained by the former method (-88.6×10^3 tons).

Vertical mixing by wind was also studied from the salinity distribution and the results show that the wind of a speed smaller than 10m/sec can not strongly stir the stable zone between salt and fresh water.

The longitudinal distribution of salinity along the rivers flowing into Lake Kojima was analysed with reference to the diffusion equation, and the amount of salt carried into the river from the polder lands and the value of the diffusion coefficient were estimated from the observation data.

A Study of Infiltration and Runoff on a Natural Forested Slope

By Kazuo OKUNISHI

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, Dec., 1966, pp. 157-171 (in English).

Abstract

An investigation of infiltration and runoff was carried out from 1960 to 1965 on a natural forested slope. The test plot used has a dimension of 10m $\times$20 m, an inclination of 27°, and an profile of the upper and the lower litter layers, the humus layer, and the sandy clay layer. The vegetative cover is a mixture of Japanese cyresses, pines, bushes and ferns.

Observation was carried out concerning rainfall intensity, areal distribution of rainfall, intensity of runoff from each soil layer, and other elements such as soil moisture and temperature. Runoff was observed by collecting the runoff water through a specified layer at the lower end of the test plot taking care that the slope was kept as undisturbed as possible. The mean net precipitation onto the soil surface was found to be proportional to the value obtained by the rainfall intensity meter, the coefficient being 1.02.

Runoff from the upper litter layer takes place when rainfall intensity exceeds 0.08 mm/min. Runoff from the entire litter layer is proportional to rainfall intensity when the latter is smaller than 0.2 mm/min and increases acceleratedly when the latter exceeds 0.3 mm/min. Runoff from both the litter layer and the humus layer is proportional to rainfall intensity for the range of rainfall intensity from zero to 2 mm/min.

The above results lead to the following conclusions about the mechanism of infiltration and runoff. The litter layer and the humus layer have a large infiltration capacity and pure surface runoff cannot occur. The litter layer can transfer the filmy water sticking on each litter snrface sideways along the surface of the catchment and thereby gives a component of runoff whose quantity is proportional to the rainfall intensity, but limited within 0.015 mm/min. When the rainfall intensity exceeds 0.3 mm/min the flow through the humus layer overflows to the litter layer and the flow through the litter layer increases again with the rainfall intensity.

Runoff through the litter layer and hums layer obeys Darcy's law and is proportional to the detention of water in these layers. Seepage of rainwater from the humus layer down to the sandy clay layer also seems to be proportional to the detention. Therefore infiltration, runoff and detention all become proportional to rainfall intensity.

On the Deformation of Frozen Soil

By Yoshiaki FUKUO and Yoshio ARIGA

Special Contributions of the Geophysical Institute, Kyoto University,
No. 6, Dec., 1966, pp. 187-192 (in English).

Abstract

It is well known that the mechanical strength of soil is extremely dependent on the cohesion between soil particles and water. As the soil is frozen, its cohesion will be highly increased by the cementation of particles due to ice formation. However, water in a very small pore, remains unfrozen owing to adsorbtion on the particle surfaces and this unfrozen water has a significant effect on the deformation of frozen soil by its fluidity. Recently, in our country, the soil freezing method has been used in engineering projects. In construction work, the phenomena of soil freezing must be understood exactly and fully for safety reasons. From this point of view, the deformation of frozen soil has been examined in a compressional experiment.

A block of soil was sampled from the alluvial layer in Tokyo. The block was divided into several pieces. Each piece was moulded into cylindrical form 5 cm in diameter and 9 cm in height. A moulded piece was put in a case and was immersed in a brine tank kept at a temperature of -15 ± 0.5°C. After exactly five days of immersion, a frozen piece was taken out of the case. The piece expanded about 3 mm during freezing in an axial direction only because of casing restraint. Then, one end of it was scraped off so that the piece was again 9 cm in height. Soon after scraping, the piece was coated with grease all over its surface and was set on the base of an axial compressive device. The test piece was compressed in its axial direction by the weight hung on the end of the lever arm. The contraction of the piece was recorded automatically in an accuracy of ± 0.02 mm.

All pieces underwent creeping deformation and it was seen that the strain increased linearly with the logarithm of time of loading for each constant load up to 60 kg/cm^2. Using these results, the values of the linear coefficient were calculated by the least squares method for respective straight lines. The result of the calculation showed that its linear coefficient was not proportional to the compressive load.

Paleolimnological Study on Ancient Lake Sediments in Japan

By Shoji Horie

Verhandlungen, Internationale Vereinigung für Theoretische und Angewandte Limnologie
Bd. 16, Dezember, 1966, S. 274–281 (in English).

Abstract

There are several ancient lakes in Japan, namely Biwa-ko, Aoki-ko, Nakatsuna-ko, Kizaki-ko, Suwa-ko, Nojiri-ko, and Yogo-ko. They apparently appeared before Holocene when we consider C^{14} dating and mammal fossils. The writer has a great interest in obtaining core samples for the purpose of studies both of the developmental history of lakes and of the reconstruction of the pleistocene climatic changes.

In a 10-m core sample at Yogo-ko, fluctuation of the trophic stage, particularly a limnetic accident which is correlated with interstadial between two expansions of glaciers, is recognized. In addition, ages of low lake level are tentatively correlated with the recurrence surfaces in Northern Europe. It suggests that the trophic stages are well controlled by the climatic changes.

In Suwa-ko, the writer found peat at a depth of 6 m. It indicates the existence of two limnetic cycles, interrupted by bog deposits which is correlated with the extremely low lake level age in Yogo-ko.

From his 4 m core of Kizaki-ko, the writer found the fact of low production in older times, shown by the existence of clay. In the diagram of trophic stage fluctuation, rather oligotrophic stages were estimated from an accumulation rate of 0.2 mm per year as 3,500, 6,500, little more than 7,500, 10,500, 13,000, 15,000, and 17,000 in years B. P. Fossil evidence and C^{14} dating indicate that a colder climate prevailed in Japan in $11,330 \pm 260$, $11,840 \pm 290$, $13,130 \pm 230$, $15,750 \pm 390$, $15,850 \pm 360$, $16,050 \pm 170$ years B. P. Such coincidece of both features is noticeable.

On the Change of Salinity Distribution after the Closing of a River Mouth Part (1)

By Setsuo OKUDA and Seiichi KANARI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 505-512 (in Japanese).

Abstract

Model experiments on the motion of salt water in the upstream region of a river mouth dam were carried out in order to investigate the salinity distribu tion and prevent salt intrusion.

The same value of Richardson number was given for the model and prototype so as to provide similar conditions.

The Model dam was set in the center of the experiment flume of 7 m×0.5 m ×0.5 m and the necessary density difference was made by the use of NaCl solution. White sand of 2mm diam. was put on the flume floor and the arbitrary geometrical form of the water bottom was easily lealized with the local movement of the sand by hand.

The following experiments were carried out with various combinations of density difference and flow rate.

(i) Settling down of intruding salt water in the hollow.

In order to prevent salt water from rising up and intruding through sluice or lock gate, the artificial hollow was constructed at the bottom of the upstream side of the dam and the settling of salt water in the hollow was checked under various intruding conditions.

The results show that the construction of the hollow can stop the rising up of salt water effectively even in the case of a very small density difference.

(ii) Removal of salt water from the hollow.

In order to prepare for the successive intrusion of salt water, the settling salt water has to be removed from the hollow.

The methods of removal are as follows.

(1) Increase of flow velocity of fresh water over the hollow

(2) Stimulation of interfacial resonance oscillation by periodical discharge of fresh water

(3) Utilization of suction pipe with exit in the high velocity region near the gate

(iii) Blocking of salt intrusion with water jet.

In order to prevent salt intrusion along the river bed, a vertical water plane jet was spouted out from the pipe set in the bed, and flow pattern and salinity distribution were observed to check the effect of the jet on salt intrusion. Under specified conditions, salt intrusion can be effectively stopped with a water jet.

On the Design of Automatic Water Samplers. Part I. A Simple Sampler for Small Streams.

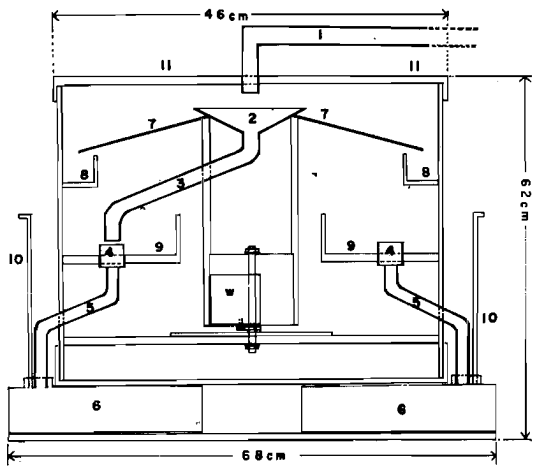
By Yoshiaki FUKUO, Seiichi KANARI, Kazuo OKUNISHI and Koji YOKOYAMA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 523-528 (in Japanese).

Abstract

It has been recognized that the chemical analysis of stream water offers a valuable method for the estimation of the degree of rock weathering and the consideration of the process of runoff water. For such investigations, it is necessary to carry out the sampling of stream water periodically even in stormy weather. So we have designed an automatic water sampler which can easily be set beside any stream. A diagramatic view of this sampler is shown in the figure.

The lowest part of the sampler consists of twenty four water containers arranged in a circle. Each container has a receiver, a conduit pipe and an air-purge pipe and its volume is about one litre. Stream water flows into the intake pipe and pours into the water container through the delivery pipe, receiver and conduit pipe. The delivery pipe is rotated by a clock around the central axis of the sampler. The speed of its rotation can easily be altered by the combination of driving gears of clock. Each container stores stream water at the interval of one hour in the case of one revolution per day.



Figure, Diagramatic view of the water sampler. 1—intake pipe, 2—funnel-shaped collector, 3—delivery pipe, 4—receiver, 5—conduit pipe, 6—water container, 7—overflow shade, 8—overflow drain, 9—overflow drain, 10—air purger, 11—roof, w—driving clock.

Special care is taken so that stored water in the container is in contact with air only in the air purge pipe, in order to prevent a change in the chemical character of sampled water.

This sampler was set beside a river upstream and success fully operated as expected. In future, we intend to improve the sampler so as to make it lighter and capable of catching the suspended matter in stream water.

On the Volumetric Expansion of Soil Due to Freezing

By Yoshiaki FUKUO, Tetsuji KATO and Yoshio ARIGA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 529-536 (in Japanese).

Abstract

In cold regions, considerable uplift of the ground surface is often seen as the soil is freezing. This uplift is called "Frost heaving". Uneven heaving of the ground surface causes heavy damage to the base of railways, road surfaces and the foundations of buildings. For the prevention of such damage, the behavior of frost heaving must be understood exactly and fully. As a preliminary to this investigation, we measured the volumetric expansion of soil due to freezing under various compressive loads.

Blocks of silty sand were sampled in the alluvial layer in Osaka. The soil sample was filled up undisturbedly in a brass cylinder which had an inner diameter of 5 cm and a height of 10 cm. A piston was put on the top of soil in the cylinder and a thermister probe was inserted into the center of the sample from the bottom of the cylinder. This cylinder was immersed in a brine tank kept at constant low temperature in order to cool the sample. As the water in the soil was frozen, the soil sample expanded in an axial direction only because of casing restraint and lifted the piston which was pushed down by the weight hung at the end of the lever. The temperature of the sample and the displacement of the piston were measured continuously by self-recorders.

The temperature of the sample decreased from room temperature to about -2°C and rose rapidly to about 0°C owing to the spontaneous nucleation of soil water and decreased again to the brine temperature after a few hours. The cooling rate of each sample was changed by altering the brine temperature. It was found that the greater the cooling rate, the higher was the spontaneous nucleation temperature.

The piston began to move upwards at spontaneous nucleation and reached final uplift after about an hour. In order to compare the behavior of freezing expansion in a vertical direction in situ with one in a horizontal direction, the brass cylinder was filled up with the soil sample in such a way that the axis of the cylinder coincided with the plumb line at sampling position or lay on the horizontal plane. It was found that in a horizontal direction, the amount of freezing expansion was about 5 % of the initial height of the sample at no load, decreased according to the increase of load and was about 2.5 % at 20 kg/cm^2 and that in a vertical direction, the amount of expansion was about 2.5 % regardless of the compressive load from 0 up to 20 kg/cm^2.

Underwater Acoustical Telemetry for Oceanographical and Limnological Research

By Seiichi KANARI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 537-545 (in Japanese).

Abstract

The acoustic telemetering device which was designed for measuring depth, water temperature and turbidity in reservoirs and lakes, was applied to the observation in Lake Biwa and the Amagase reservoir, and some typical temperature stratifications were clearly recorded. In the observation in Lake Biwa, the pressure senser did not act correctly, and the depth determination was made by the wheel gauge. In the observation in the Amagase reservoir, the improved pressure senser worked correctly and a perfect recording was made in five channnels; upper standard, water temeperature, turbididity, pressure and lower standard. In this observation, the reading of the depth signal (pressure) was compared with the reading of the wire length, from which it was found that the error in depth determination is less than ± 2 m.

There was a discrepancy between the records of the temperature profile observed in the same thermocline in accordance with the descending speed of the instrument. This test was carried out at two different descending speeds of about 3 cm/sec and 12.5 cm/sec at the same station and almost the same time. The time interval between the above two measurements was about 5 minutes and the temperature gradient of the thermocline, therefore, may be considered as the same through out the measurement, although the discrepancy of the temperature in the thermocline reached about 2.7°C. The very different indication of water temperature was due to the thermal time constant of the temperature senser and the time constant of the oscillator circuit. This indication difference is given by the equation, $T_R-T_2=-\gamma\tau+[(T_1-T_2)+\gamma\tau]\exp\left(-\frac{Z_2-Z_1}{V_D\tau}\right)$. Where, γ is a constant and $\frac{\gamma}{V_D}$ is the mean temperature gradient of the themocline between the depth Z_1 and Z_2, V_D is the lowering speed of the transmitter, τ is the total thermal time constant of the transmitter, and T_R is the observed value of the water temprature at $Z=Z_2$. From the above equation, the thermal time constant of the transmitter was evaluated as $\tau \geqq 12$ sec, which is too large for measuring the profiles of sharp temperature gradients quickly.

Rainfall and Runoff on Mountainsides
···Part 2. Mechanism of infiltration and runoff···

By Kazuo OKUNISHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 547-555 (in Japanese).

Abstract

This paper describes the results of the investigation on the mechanism of runff from a natural forested slope carried out at a test plot in the Kamigamo Geophysical Observatry from 1963 to 1965 succeeding the investion on runoff from the litter layer in the same test plot from 1960 to 1962. (Annuals, Disaster Prevention Research Institute, Kyoto University, No. 6, pp. 156-165).

Besides the observation of the intensities of rainfall and runoff at each minute, continuous measurement of the distribution of soil temperature and moisture was carried out in 1963 - 1964 and in 1964 - 1965 respectively. The areal distribution of rainfall and the interception by vegetative cover was determined by the rainfall intensity meter, five nonrecording rain gauges, and a standard type recording rain gauge set at the top of the sope (open ground.) Thus it was found that the mean net rainfall intensity is equal to the value of the rainfall intensity meter multiplied by a constant which is 1.02 on an average but varies with different rain storms.

The change in the distribution of soil temerature due to infiltration of relatively cold rainwater was so small that it could not be distinguished from the noise due to the change in atmospheric temperature and radiation. The change in the distribution of soil moisture due to infiltration of rainwater can be divided into shor-term change and long-term change. The short-term change showed that rainwater reaches a depth of 5 cm in the sandy clay layer soon after the beginning of the rainfall. The long-term change showed that the rainwater can infiltrate to a depth of 15 cm in the sandy clay layer 40-60 days after the beginning of the rainy season.

The runoff from both the litter layer and the humus layer is fairly proportional to rainfall intensity for the variation of the latter from zero to 2 mm/min, though the runoff from the litter layer is not so proportional to the latter. Since the infiltration capacity measured by a buffered infiltrometer was 10 mm/min, the runoff observed is not the pure surace runoff but a sort of subsurface runoff whose quantity obeying Darcy's law is proportional to the detention of water in the litter layer and the humus layer.

Development of Zones of Weakness and Resultant Rockslides Caused by Geochemical Weathering in the Daido-Gawa Area

By Yasushi KITANO, Setsuo OKUDA, Kazuo OKUNISHI and Ryuma YOSHIOKA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 589–598 (in Japanese).

Abstract

Y. Kitano (1966, 1967), one of the authors, estimated the amount of chemical elements which were dissolved from rocks through the interaction between rocks and natural waters, and showed the possibility of foretelling zones of weakness and resultant rockslides caused by geochemical weathering, from the chemical composition of natural waters.

For the investigation of the development of the zones of weakness and resultant rockslides caused by geochemical weathering in the Daido-Gawa area, the authors determined the concentrations of chemical elements contained in natural waters collected in both fine weather and rainy weather (Ca. 100 mm) conditions from July to August 1966.

Temperature and pH values were measured in the field and chemical constituents such as Na^+, $Ca^{2+} + Mg^{2+}$, Cl^-, SO_4^{2-}, HCO_3^- and soluble SiO_2 were determined in the laboratory.

The authors showed the difference in chemical composition between both water samples, and studied the mechanism of the difference. They discussed the chemical interactoin between precipitation and rock or soil, to clarify rockslides attributed to geochemical weathering in the Daido-Gawa area. It may be considered:

(1) The concentrarions of $Ca^{2+} + Mg^{2+}$ and HCO_3^- containd in the rivers Kishioji and Tenjin were very low, regardless of weather conditions, but the concentration of soluble SiO_2 was the same as the ordinary value in natural waters. This means that the chemical interaction between rocks and natural waters is not active and resultant rockslides caused by geochemical weathering have not easily occurred in those areas.

(2) The concentrations of $Ca^{2+} + Mg^{2+}$ and HCO_3^- contained in the river Tahara were remarkably high. In heavy rain the concentration of soluble SiO_2 was lower than that of other rivers, while in fine weather it was normal. One of the simplest considerations explaining these phenomena is as follows; there is a zone of limestone in this area.

(3) From a geochemical point of view, the concentrations of dissolved elements in the Daido-Gawa area are similar to those in natural waters, rocks in this area are silicate rocks and the degree of geocemical weathering is very low.

On the Problem of the Crustal Deformation in Lake Basin

By Shoji HORIE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 599-606 (in Japanese).

Abstract

When we deal with crustal deformation, there are four points of view. They are 1) structural geological and structural geomorphological time unit, 2) Pleistocene geological time unit such as the earthquake fault, the marine terrace, the stream terrace, and the lacustrine terrace, 3) geodetic time unit, and 4) daily or monthly time unit expressed in the tiltmeter. However, it is extremely difficult to deduce the mode of minor crustal deformation which took place in the past (at least in pre-historic times) since the geologcal and geomor phological evidence is obscure. The writer has tried to find such evidence in the sedimentary record since it keeps every trace of such past events. He examined the paleolimnological data, particularly geochemistry in the core sample of Lake Yogo-ko. He used phosphorus (inorganic) content and residue content as an indicator of the precipitaion and nitrogen content as a marker of the trophic stage, i. e. oligotrophy and eutrophy corresponding to the precipitation in this closed lake, and carbon content as an indicator of the amount of allochthonous organic material. After examining the climatic influence, the writer picked up two low N/C horizons which do not correspond to the climatic events ; he regards them as the result of the minor crustal deformation in this tectonic lake Yogo. On the basis of the radiocarbon dating on the wood contained in former lacustrine sediments, the age of such minor crustal deformation which shows the mode of excavation of this lake basin is regarded as approximately 2,100 years B. P. and 7,800 years B. P.

Late Pleistocene Climatic Changes inferred from the Stratigraphic Sequence of the Japanese Lake Sediments

By Shoji HORIE

Means of Correlation of Quaternary Successions (INQUA VII Congress Proceedings Vol. 8), Salt Lake City, University of Utah Press, 1967, (in English).

Abstract

As the result of a paleolimnological study of ancient lake sediment in Japan, the following phenomena were found.

In a 10-m core sample from Yogo-ko, fluctuation of the trophic stage is easily recognized. A remarkable point is a limnic accident at a depth of about 6 m. On the basis of the various kinds of chronological data, its age might be correlated with the time of decrease of precipitation, that is an interstadial between two expansions of glaciers. The other notable point is that ages of low lake levels are correlated with the recurrence surfaces in Northern Europe.

In a 4-m core from Kizaki-ko, located near central Japanese high mountains in which Pleistocene glaciation took place, low production in older times was shown by the existence of clay. In the diagram of trophic stage fluctuation, rather oligotrophic stages were estimated from an accumulation rate of 0.2 mm per year as 3,500, 6,500, little more than 7,500, 10,500, 13,000, 15,000 and 17,000 years B. P. Coincidence between the oligotrophic feature and the colder climate proved by fossil evidence and C^{14} dating is noticeable.

In a 2-m sample from Biwa-ko, a similar tendency in the fluctuation of lake trophy was noted. Therefore, the influence of climatic changes is regarded as more effective than crustal deformation, even in a lake where the earth's crust is unstable.

Limnological Studies of Lake Yogo-ko (I)

By Shoji HORIE

Bulletin of the Disaster Prevention Research Institute, Kyoto University.
Vol. 17, Part 1, July, 1967, pp. 1-8 (in English).

Abstract

Lake Yogo-ko is located to the north of Lake Biwa-ko. The limnetic history of it probably has a close connection with the features of strucral geology of the surrounding area. The writer is of the opinion that Lake Yogo-ko continued to eixst for a considerable length of time after it was separated from Lake Biwa-ko by reason of the effect of the crustal deformation, that is the western subsidence and the southward inclination of the earth.

The writer has recognized an existence of six terraces around Lake Yogo-ko. It is of interest that Lake Yogo-ko might have been connected with Lake Biwa-ko during the building of T (Terrace)-2, 3, 4; afterwards it was separated from the latter and its independent limnetic history began. The age of T-3 is regarded as 28,500 ± 2,500 years B. P. on the basis of radiocrbon dating. In addition, the age of wood contained in T-5 deposits was 3,180±180 years B. P. Presumably, the level of Lake Yogo-ko at that time was lower than before since that wood was 2 m below the rice fields and was contained in the lacustrine sediment; afterwards it rose to a somewhat higher altitude than the present level and then dropped again to the T-6 level. As it is probable from a consideration of the geomorphology of the surrounding area that Lake Yogo-ko was naturally a closed lake, the main cause of such fluctuatuation of level seems to have been the former climate. Accordingly, it is expected to yield valuable information for the investigation of paleolimnology. It is also an appropriate subject for the study of water budgets.

In view of the fact that the separation of Lake Yogo-ko from Lake Biwa-ko occurred post-T-4 but pre-T-5, its own age is somewhere between 28,500±2,500 years B. P. and 3,180 ± 180 years B. P.

From the various points of view, Lake Yogo-ko is certainly a model which illustrates the type of crustal deformation and climatic change that affected the ancient lake of Biwa.

On the Process of Sedimentation in Lake Biwa-ko, An Ancient Lake in Japan

By Shoji HORIE

Jubilee Publication in the Commemoration of Professor
Yasuo Sasa, Dr. Sc., Sixtieth Birthday Sept. 1967, 83-91 (in English).

Abstract

The writer has been engaged in the study of the sediment in Lake Biwa-ko and obtained data concerning the mechanism of the sedimentation. Unexpectedly, contents of organic material, nitrogen, and calcium carbonate are much greater in the deeper zone than in the shallower, littoral zone. Such a deeper zone, i.e. hypolimnion, contains a sufficient amount of dissolved oxygen. The boundaty between the deeper zone and shallower zone is approximately 15 m in water depth. The writer interprets this fact as the result of water temperature and allochthonous inorganic material. As the littoral zone is warmer, organic material is quickly decomposed; then, nutrient salt dissolves in lake water. In addition, allochthonous inorganic material is continuously supplied to the littoral zone from the inflowing rivers. The writer also has data indicating the close connection between currents and depositon. The fact of poor sorting in the center of the counterclockwise movement of the current might be due to the gathering of particles in all sizes that is the convergence of suspensoid. The larger amount of organic material in the same spot also suggest the existence of that mechanism.

Limnological Studies of Lake Yogo-ko (II)

By Shoji HORIE

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 17, Part 2, Oct., 1967, pp. 31-46 (in English),

Abstract

From the historical view of the limnological studies of Lake Yogo-ko, it is regarded that this lake is either a mesotrophic or less advanced eutrophic lake type. However, it is problematical whether the lake has always been the same type since its first eutrophication. In tectonic lakes, a basin-making crustal deformation might have been active, and therefore the oligotrophic state has persisted despite the immense passage of time. If crustal movements work out in the shallowing of the lake basin, eutrophication may advanee in a relatively short time. Accordingly, such crustal deformation is extremely important for lake-trophy and must be taken into account in an unstable country like Japan. The other important factor which controls lake-trophy is climatic change. In contrast to the tectonic accident, the climatic accident happens on a wider scale. Thus the trophic stage of any lake is an entirely contemporary phenomenon and we can not simply estimate past and future lake-trophy from the present situation.

After the monthly observation for a year on physicochemical feaures of Lake Yogo-ko, the writer has clarified the present situation of this lake. The process of the formation of the hypolimnion, fluctuation of the amount of both dissolved oxygen and carbon dioxide, variation of pH and alkalinity has been shown. One peculiarity is an increment of dissolved oxygen at lower depths. The origin might be owed to either or both of the derivation from underground water and/or the influence of lake basin morphology.

As a result of the writer's study, it is verified that Lake Yogo-ko is progressing towards eutrophy at present as in the case of many lakes in Japan.

Geochemical Study of Ground Waters in the Matsushiro Area
Part 1. Chemical Composition of Ground Waters

By Yasushi KITANO, Ryuma YOSHIOKA, Setsuo OKUDA
and Kazuo OKUNISHI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 17, Part 2, Oct., 1967, pp. 47-71 (in English).

Abstract

The Matsushiro swarm earthquakes occoured in and around the Matsushiro town area of Nagano Prefecture in August 1965. It seems possible that a change in the conditions under the ground area can be expected through a change in the chemical composition of the ground waters. Knowledge of conditions under the ground is both useful and important for understanding the mechanism of the occurrence of the Matsushiro swarm earthquakes.

For the investigation of hydrochemical features in this area, the authors measured the change with time in the chemical composition of ground waters. That is, from September 1966 to February 1967, ground water samples were taken monthly and the chemical composition was determined.

Temperature and pH values were measured in the field and chemical constituents such as Na^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, SO_4^{2-}, borate B, and soluble SiO_2 were determined in the laboratory.

These results make it possible to say the following: with the increasing activity of the Matsushiro swarm earthquakes, the content of most dissolved chemical constituents as well as the amount of ground waters greatly increased from September 1966 to February 1967. The greatest increase during our observations occurred from September to October 1966.

(1) The content of carbonate material including the carbon bioxide gas of ground waters increased greatly with time, in other words, with the activity of the earthquakes.

(2) The concentrations of calcium and chloride ions increased most remarkably with time, among dissolved ions.

(3) The concentrations of sodium and bicarbonate ions increased with increasing concentration of chloride ions.

(4) The concentrations of magnesium and borate ions increased proportionally with the increasing concentrations of calcium and chloride ions.

(5) The concentration of sulfate ions increased only a little in spite of the increase in chloride concentration.

(6) The concentration of soluble silica did not change, independent of time and of the increase in the concentration of chloride ions.

(7) The temperature of the ground waters increased in spite of the decrease in the atmospheric temperature and the amount of ground waters was independent of the amount of precipitation.

These facts indicate that ground waters are not influenced either directly or greatly by surface waters and that these seem to be derived from an origin deep under the ground.

Unfrozen Water Content of Artificially Frozen Soil

By Yoshiaki FUKUO and Yoshio ARIGA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 17, Part 2, Oct., 1967, pp. 73-77 (in English).

Abstract

The study of unfrozen water is significant for clarifying the mechanism of water movement accompanied by frost heaving. It is well known that when soil containing water freezes, it expands much more than one would expect from expansion due to the freezing of the water that is in the soil. This shows that the water must be available for a large amount of frost heaving and that water movement from the watertable exists.

The freezing temperature of water in soil is mainly related to the state of stress (PF) produced in the soil water by several effects. Water in soil under the adsorption force produced by the soil particles will have a very low freezing point and can not be frozen easily. This unfrozen water film plays the part of the waterway through which the water moves and has the free energy associ ated with the phase change to ice. It is this free energy that produces the force to suck up the water from the watertable.

The authors measured the content of unfrozen water (expressed as a perce ntage of the dry weight) of soil samples frozen artificially in the laboratory with a specially designed calorimeter. The sample was cooled at specified temperatures over a definite time in a brine cooling vessel.

In this measurement, the range of freezing temperature and the periods of freezing were taken for -4 to -28 °C and 20, 40, 91 hours respectively.

The cooling rate in these experiments was from 0.15 to 0.30 °C/min, which was calculated at the supercooling region from the cooling curve.

It was seen that the unfrozen water content of frozen soil depends on both the freezing temperature and the freezing time. An interesting phenom enon is that the unfrozen water content, which decreases as expected with a longer freezing period, increases with a lower cooling temperature over a freezing period of 20 hours.

It may be suggested that rapid freezing causes the inclusion of the soil particles in the ice and, at the same time, brings the increase of the prressure to be applied to soil particles, which decreases gradually with time owing to the relaxation of stress.

Study on the Relation between Local Earthquakes and Minute Ground Deformation
Part 3. On Effects of Diurnal and Semidiurnal Fluctuations of the Temperature and Atmospheric Pressure on Ground Tilts

By Torao TANAKA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 2, Jan., 1967, pp. 17-36 (in English).

Abstract

The diurnal and semidiurnal effects of the atmospheric temperature and pressure upon the ground tilt observed by tiltmeters of the horizontal pendulum type at two stations in Wakayama City, Japan are investigated with the use of one year's data from July 31, 15h00m, 1960 to July 31, 14h00m, 1961 (UT). In the first half of the paper, monthly amplitudes and phases of the M_2, S_2, O_1, and S_1 constituents have been calculated in respect of the ground tilts, oceanic tides, atmosphric temperature and pressure by the Fourier transform method.

Intercorrelation between the ground tilts and meteorological and oceanic disturbances have been examined with reference to the amplitude and phase fluctuations. In the latter half of the paper, coefficients for effects of the temperature, atmospheric pressure and its time gradient upon the ground tilts have been determined from their mean daily variations by the method of least squares. Influence of the atmospheric pressure is especially remarkable on the S_2 constiuents of the ground tilts at both stations. The mode of the daily ground tilting observed at the Akibasan station, which was mainly caused by thermal deformation at the ground surface, shows seasonal variation. Its amplitude is large in the summer and small in the winter, and the northward tilting in the morning is conspicuous in the summer, the pattern of which is very similar to that of the buckling motion of a building of simple form. Two pairs of tilmeters installed in the same direction on one concrete base behave in a different manner for diurnal and semidiurnal changes of the temperature and pressure, from which it is concluded that these effects have local characteristics detectable even when the tiltmeters are placed so close to each other. This should be given due consideration in observation of minute deformations of the ground, and in the evaluation of tidal constituents, especially in that of the S_2 constituent.

An estimation of the effects of the atmospheric pressure gradient is attempted for atmospheric tidal waves, the obtained value being $7''$ per 1 mb/km; however, the direction of the ground tilt is opposed to that expected from the loading influence due to barometric pressure.

Processing of Seismic Data Using Analog-Digital Converter (II) ···An Application to the Volcanic Micro-tremors of the Volcano Aso···

By Tamotsu FURUZAWA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 51-61 (in Japanese).

Abstract

The volcanic micro-tremors of the Volcano Aso recorded on magnetic tape were digitized with the A-D converter. The four micro-tremors of the digitized data, named KT-2-9, KT-2-10, KT-2-12, and KT-4-14, were detrended, and filtered for mode separation with 4 cps low-pass and 1 cps low-pass digital filters. Particle motions were obtained in each period range in order to investigate the direction of motions and its change with time. For KT-4-14 the normalized correlation coefficient P_{XY} $(=\sum X_iY_i/\sqrt{\sum X_i^2 \cdot \sum Y_i^2})$ as described by Phinney and Smith was obtained as an example of analysis easily carried out automatically.

It is found that the two micro-tremors, KT-2-9 and KT-2-10, have the same change with time in regard to period and orbit, especially within the period range of 0.25 to 1 sec. The directions of the particle motions are approximately SH type. But the modes of the period range of 2-3 sec indicate the different direction of arrival. For KT-4-14 the particle motion is different from other tremors and it is considered earthquake tremor. The P_{XY}-functions have a high value near the arrival of the P wave, but near the arrival of the S wave no very distinct peak, which may be attributed to the overlap of some different phases.

Observations of the Tidal Strains at Osakayama Observatory, Report II

By Izuo OZAWA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 63–75 (in Japanese).

Abstract

Observations of the tidal strains and the tidal tilts of the earth's surface with several extensometers in the some directions and with a recording water-tube tiltmeter have been carried out at Osakayama Observatory since 1947.

Although Sassa type extensometers had been used formerly, the highly sensitive extensometers of new types, called the H-59-B type for the horizontal components, and the V-59-B and D types for the vertical components, respectively, have been devised by the present author, and have been being usually used.

Many precise observations of the some horizontal and the vertical components have been performed with them, and the analyzed periods of the tidal analyses have amounted about fifty months.

According to these analyses and the calculations of the tidal numbers, the values of l_2, h_2 and their radial gradients have been obtained as follows

$$h_2 = 0.590 \pm 0.047, \qquad l_2 = 0.088 \pm 0.012,$$

$$a\frac{dH_2(a)}{dr} = -1.475 \pm 0.025, \qquad a\frac{dL_2(a)}{dr} = -0.680 \pm 0.049.$$

The maximum elongations of M_2 and O_1-components of the tidal extension are found in the direction of S 57° E and in that of S 49° E, respectively, i. e. the main axes of the ellipses of the horizontal sections of the strain components are both deflected to the direction of the north-west to the south-east. One of the causes of the axes deflecting may be found that the earth's crust is not homogeneous horizontally throughout the Japanese Islands. The deflections of the main axes of these tidal strain ellipses almost agree with that of the gradient of the increasing thickness of the crust. i. e. these axes are almost orthogonal to that of the Japanese Islands. The above values of the tidal numbers have been calculated by considering the anisotropy of the crust.

Harmonic analyses of the observations by means of a recording type (Eto type) water-tube tiltmeter have heen performed. According to the results, the ratio of the diurnal tide (O_1) to the semi-diurnal tide (M_2) is very much larger than that of the theoretical direct one.

The present authtor has also devised a rotational strainmeter in order to observe the rotational and shear strains directly, and he has carried out the expected observations with this instrument very well.

On the Observation of the Crustal Deformation at Donzurubo Observatory (Preliminary Report)

By Michio TAKADA, Toshio KOBAYASHI and Masaru YAMADA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 141–147 (in Japanese).

Abstract

For the purpose of studying crustal deformation, research carrying out into the relations between crustal deformation and earthquake occurrence and finding out some clues for earthquake prediction, the Donzurubo Crustal Movement Obsevatory was established in April, 1966. This Observatory is situated at 135° 40′ E and 34°32′ N, Anamushi, Kashiba-cho, Kitakatsuragi-gun, Nara Prefecture. The observing galleries are adapted abandoned air-raid shelters which were excavated by the military at the time of the Second World War some 25 years ago and a cross-section of these galleries is about 4.0 m in width and about 3.2 m in height. The observation room is a part of the galleries divided by partition walls made from concrete blocks and is not much affected by the open-air temperature. The neighbouring formation is formed by the Donzurubo beds, which belong to the Nijo Groups made from lava and volcanic ash thrown up by the volcanic activity in the Late Miocence of the Tertiary period and these surrounding rocks are chiefly tuff and tuff breccia.

In this observation room, six Super-Invar-Bar Extensometers (6 component type), a Super-Invar-Bar Extensometer, two Super-Invar-Wire Extesometers (Sassa type), ten Tiltmeters with horizontal pendlnm of Zöllner suspension type and four Tiltmeters of water-tube type were set up in May, 1966. Observations of ground-strain and ground-tilt using these various instruments have been carried out since then.

These observational facts are shown chiefly because the observation time was not long enough for any conclusions to be reached about the various problems.

Study on Relation between the Local Earthquakes and the Minute Ground Deformation at Wakayama (Part 5)

By Torao TANAKA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 149-155 (in Japanese).

Abstract

Results from digital filterings of the tiltmetric data observed at Wakayama before and after the local earthquakes of Nov. 14, 1960, are presented. The three earthquakes which occurred on that day seem to be of the greatest magnitude among local earthquakes in this district.

Records of the temperature at the Wakayama Meteorological Observatory and pressure at the Akibasan station have also been analysed by the same procedure in order to examine their influence upon the ground tilt. One high-pass and three band-pass filters were used namely, 0~5 hours high-pass, and, 5~7, 7~11 and 13~23 hours band-pass filters. On the whole, correspondence of the filtered curves of the ground tilt with those of the temperature is not so apparent in the present periodic ranges. Partial resemblance between the filtered tiltgrams and barograms is seen in the shorter periodic range. At Akibasan, concurrent observation of the ground tilt by two pairs of tiltmeters on one concrete base has been carried out and in the previous work it was ascertained from this observation that the diurnal and semidiurnal influence of the temperature and pressure recorded by the tiltmeters at the corner of the base is larger than that recorded by the tiltmeters on its central part. Although the amplitude fluctuation of the filtered tiltgrams obtained by the tiltmeters at the corner is larger, as expected, than that of the central part, the former can not be explained by simple magnification of the latter and the modes of their vicissitudes are different to each other, which suggests that the influence of the temperature and pressure is a very local characteristic. The noise level of the filtered results of the ground tilt of the N-S component observed at Akibasan is lowest compared with the other results, and a peculiar tilting motion of the ground is seen only on the high-pass filtered tiltgram of this component at the time of occurrence of the three earthquakes, the amount of which is estimated to be about 0.002″.

The Observation of Crustal Deformations at Iwakura, Kyoto (I) ···On the Influence of the Precipitation on Extensometers and Tiltmeters···

By Shuzo TAKEMOTO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 157-164 (in Japanese).

Abstract

The observation of crustal deformations using superinvar bar extensometers and horizontal pendulum type tiltmeters has been carried on since 1964 at Iwakura observatory.

This observatory is located at 35°05′01″ North Latitude and 135°48′11″ East Longitude and the elevation is about 150 meters referred to mean sea level. The underground observation gallery has a length of 33 meters and part of it is covered with concrete. It is separated into three rooms by three steel doors. Instruments are set up in the deepest room.

Generally, when we want to observe crustal deformations for the purpose of prediction of earthquakes, careful consideration must be given to the influences of meteorological changes, for example, the change of the atmospheric pressure, the room temperature, the discharge of underground water and the precipitation.

Of these influences, that of precipitation has been the most remarkable during the past 16 months at Iwakura observatoy.

Observed ground strain and ground tilt caused by the influence of precipitation have two peaks. The first peak has been found to be half a day after precipitation, on the other hand the second peak has been found to be three days after it. In some cases, the first peak has not been so clearly found but the second peak has always been clearly found without exception when precipitation has been over 30 mm/day.

We have not enough data yet to give a reliable conclusion about this problem but qualitatively it looks as if there exist some simple relations between precipitation W and ground strain or ground tilt ε_i. These relative expressions may be given in the following form:

$$\varepsilon_i = W\alpha t \exp(-t/\tau_1) + W\beta t \exp(-t/\tau_2)$$

where α and β are constants depending on the observation point and in this case at Iwakura obseratory, τ_1 and τ_2 take the following value, $\tau_1 = 1/2$, $\tau_2 = 3$ days.

On the Observation of Ground-strain and Ground-tilt in a Landslide Zone (III)

By Michio TAKADA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 491-504 (in Japanese).

Abstract

In the Kamenose Landslide zone located in Tōge, Kashiwara City, Ōsaka Prefecture, various investigations to establish a perfect stabilization plan were begun at the end of 1962. As part of these investigations the following geophysical investigations and observations were carried out.

a) Seismic prospecting,
b) Sliding movement survey and the observation of the tilting motion on the ground surface using Super-Invar-Wire Extensometers and Tiltmeters of the horizontal pendulum type,
c) Observation of subsurface deformation using a newly constructed portable underground inclinometer,
d) Observation of groundwater level by groundwater level indicators.

As a result of seismic prospecting along 9 traverse lines, the crustal structure in this area was found and the fractured zone distributed NW-SE, dividing this area into two blocks was determined.

From observations of the bend of vertical observation holes by the underground inclinometer and the groundwater level by the groundwater level indicators, the slip surface in this area was presumed to be as follows:—the slip surface was almost the boundary surface of the first layer (P-wave velocity: 0.4~0.6 km/s) and the second layer (P-wave velocity: 2.4~2.7 km/s) obtained from the seismic prospecting and the first layer was sliding.

Observations of ground-strain are being carried out by 74 Super-Invar-Wire Extensometers set up along 8 survey lines. Considering the distribution of strains, the landslide blocks in this area were also divided in two by a fractured zone and the change of strain was the largest near the fractured zone. From the investigation of secular variation and annual variation of ground-strain, it is seen that the larger the amplitude of annual variation, the larger the secular variation in the case of this landslide area is, just as in the case of the other landslide area.

It was attempted to obtain the sliding forces of divided soil blocks along the centre survey line in this landslide area with the change of water content before and after the removal of soil mass under several assumptions. As a result, it seemed that some effect of soil mass removal appeared.

In the case of small landslides at the end of 1963, peculiar variations of ground-strain and ground-tilt were found which seemed to be phenomena preceding the landslide.

On the Characteristics of Flood Waves under Various Boundary Conditions

By Kazuo ASHIDA and Tamotsu TAKAHASHI

Bulletin, Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 3, Feb., 1967, pp. 23–47 (in English).

Abstract

The behavior of flood wave in a river is very complex because of the effects of various kinds of boundary or channel conditions. To clarify these effects on floods a series of experiments were conducted in a flume (150m in length, 60 cm in width and in depth) at the downstream end of which a few kinds of boundary condition were set. By means of these experiments and appropriate theoretical considerations the authors have been able to discuss the characteristics of flood flow as follows.

a) Flood propagation through a uniform channel

As well as confirming the theoretical results arrived at hitherto, they have made clear that the flood wave simultaneously receives the flattening effect of the diffusion and the sharpening effect of the nonlinearity and according to the pattern of the hydrograph, the wave may become acute with propagation at the rising stage.

b) Flood propagation through a backwater reach which is bounded at the downstream end by a constant water depth

The following characteristscs have been clarified. If the rate of increase of the discharge is rapid enough, the stage is higher than that of the steady flow corresponding to the maximum discharge of the flood. The peak of the stage occurs before the occurrence of the discharge maximum. The propagation speed of the stage max. and of the discharge is very high and under some conditions the stage max. occurs downstream before it appears upstream. etc.

c) Flood propagation through a backwater reach bounded by a rigid weir

The authors have discussed the propagation characteristics in the storage region and in the transition region and from these discussion they have made clear that for the time lag in peak propagation, the over-flow condition plays an important role and the storage effect appears when the stage-discarge curve at the weir has a different tangent from that in the uniform channel. They have also derived the equation for calculating the length of the storage region practically.

d) Moreover the authors have dealt with cases where the flood propagates through a boundary condition corresponding to a river junction or estuary, but many problems are left for future study.

Laboratory Study of Suspended Load Discharge in Alluvial Channels

By Kazuo ASHIDA and Masanori MICHIUE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 63-79 (in Japanese).

Abstract

The greater part of the total load discharge in an alluvial channel usually consists of the susepnded load discharge. Consequently, the suspended load plays an important role in various engineering problems, such as the sedimentation in reservoirs, dredging parts and estuaries. In this paper, the authors investigated the characteristics of the suspended load and discussed its effect on a stable channel.

The experiments on the suspended load were performed in two experimntal flumes 20 cm and 40 cm in width, and the experiments for a stable channel with suspended load were carried out in a concrete channel which consists of two parts of upstream reach 40 cm in width and 20 m in length and downstream reach 80 cm in width and 30 m in length.

It was found from the experiments that the distribution of the concentration of graded sediment was able to superimpose the concentration of sand grain of every size except one of large size range. The suspended load discharge obtained experimentally by the authors did not agree with the one calculated by Lane-Kalinske's or Einstein's formla. This fact is probably due to inadequacy in evaluating the effects of the bed roughness, Karman's constant and the hiding factor of graded sediment on the suspended load discharge. The authors discussed the above points in detail and established an equation to estimate the suspened load discharge, which was introduced with an analytical model based on the experimental results.

Using the equation obtained, the authors discussed the characteristics of stable channels with suspended load, such as the variations of the size frequency distribution of bed material, shear velocity and the profile of water surface according to the variation of channel width. These were very different from the characteristics of stable channels with bed load, which showed good agreement with the experimental results.

Study on Reservoir Sedimentation

By Kazuo ASHIDA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 109-119 (in Japanese).

Abstract

Reservoir sedimentation generally takes the form of delta which is composed of four parts, namely top-set, fore-set, bottom-set and density current bed. To estimate the form of delta deposition is very important and an analytical estimation for it has been developed only for bed load transportation which corresponds to the case without bottom-set bed. It is not clear how the existence of the bottom-set bed affects the river-bed variation of top-set bed obtained by the above estimation. This may be a difficult point in applying the above estimation to actual problems.

In this paper, the auther treated the above problem theoretically and experimentally.

Conclusions were as follows.

(1) From the vertical grain-size distribution of the deposited sediment in a reservoir, it was considered that the delta progressed in such a way that the bed load moved on the surface of the beposition due to the suspended material which was approximately horizontal in the case of constant water level.

(2) For the configuratation of beds and the distance measured from the front of the delta was linear in a log-log graph except near the front.

(3) Based upon the above relation, an analytical solution representing the configuration of the top-set beds was obtained for cases both with and without bottom-set beds.

(4) The characteristics of reservoir sedimentation were clarified by the above solution. The most important point is that the existence of bottom-set beds has little effect on the river bed variation of the top-set beds except near the delta front. This means that analysis without bottom-set beds is useful for practical problems.

An Experimental Study on Sand Waves (3)

By Kazuo ASHIDA and Yuichiro TANAKA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 121-132 (in Japanese).

Abstract

One of the most important problems for hydraulic engineers to solve the mechanism of sand waves. Because sand waves occur at almost the time when the bed materials move by running water and they give rise to various difficult problems. There are three ways to approach these problems. The first is statistical treatment describing irregular sand waves quantitatively. The second is kinematical and dynamical consideration to explain their physical background. And the last is the practical method well known as the regime theory.

In this paper, the authors discussed the statistical properties of sand waves by experimental data obtained using an ultra-sonic sounding device from the first standpoint.

Characteristics of spectrum vary corresponding to the regime of bed forms. There will be a possibility to represent each regime of sand waves quantitatively by using the characteristics of the spetrum.

Comparison of the spectral density function for bed elevation as a function of time with the one as a function of distance shows that the propagation velocity of sand waves in the case of dunes is inversely proportional to the sqare root of the wave length. This explains that small scale sand waves on large scale ones propagate for downstream separating or gathering each other.

The standard deviaton of the bed elevation represents the component of the wave height. In the dune regime, relative roughness is related to the standard deviation of the bed elevation.

Flood Flow in a Compound Cross-sectional Channel

By Kazuo ASHIDA, Tamotsu TAKAHASHI and Tadatsugu TAKEMOTO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 132–145 (in Japanese).

Abstract

In this paper, the characteristics of steady flow and unsteady flow in a compound cross-sectional channel are discussed in relation to experiments conducted in an experimental flume (50 m in length, 3 m in full width, 1.2 m in one side flood plain width and 60 cm in main channel width and 19 cm in main channel depth).

The main characteristics of the flow in the compound cross-sectional channel are the retardation phenomena of the velocity of the main channel caused by the mixing of flow between the flood plain and the main channel. Hitherto calculating methods which divide the section into the main part and flood plain part overestimate the discharge in the main channel because they neglect the shear stress created by mixing at the boundary of the two parts.

The authors discussed the mixing effects for steady flow by means of measuring the three dimensioal mean velocity distribution profiles. The turbulent viscosities at the boundary deduced by these velocity profiles were great and sensitively changed the value with the variation of the depth. So they discussed the lateral mean velocity distribution on the assumption that the turbulent viscosity is proportional to depth and velocity. If the constant of proportion is correctly estimated, practical velocity distribution can be calculated by the method adopted here.

Using the results of the expeiments on steady flow, that is, that the mean velocity of the main channel hardly changes with the variation of the depth of flood plain in the range of the experiments, the authors discussed the propagation of flood flow in these cases theoreticaly and experimentally. The main results are that under this channel conditon the celerity of the flood wave is less than that which has the same hydrograph in the rectangular cross-section of the same width. The lateral flow discharge through the boundary between the flood plain section and main channel section is very small and so the lateral water surface profile is nearly horizontal in the range of the experimental hydrograph.

Secondary Flows in Curved Open Channels

By Yoshio MURAMOTO

Proceedings of the XIIth Congress of the International Association for Hydraulic Research, Vol. 1, Sept., 1967, pp. 429-439 (in English).

Abstract

The systematic study of the secondary flow which is of frequent occurence in a curved channel is a prerequisite for casting light on the internal structure of the flow in a curved channel. It must, however, be admitted that the theoretical consideration of the secondary flow in general is so complicated that most previous studies are found to have been restricted to the analysis of the behavior of the flow in a fully developed region of the curved channel.

It is intended in this paper to analyse the internal structure of the curved flow on the basis of the measurement of three velocity components and the calculation of vorticity components of the flow in curved open channels. According to the results observed for the peculiar properties of the longitudinal distribution of each mean and local vorticity component, the flow in a curved section is divided into the following three regions as a mathematical model—a generating region, a developing region and a fully developed region of secondary flow.

Next, the analytical approaches for the first and the final region are developed. The velocity distributions of secondary flow are derived from the longitudinal vorticity equation in consideration of the viscous diffusion of vorticity affected by the channel bed, and the vertical distributions of radial velocity in the generating region are discussed in comparison with the experimental results. As for the fully developed region, the radial distribution of longitudinal velocity in the upper layer unaffecteted by the wall shear is presented and examined by the use of experimental results.

The present paper is a summary of part of the research programme on flow in a curved open channel.

A Atatistical Study of Sand Waves

By Kazuo ASHIDA and Yuichiro TANAKA

Proceedings of the XIIth Congress of the International Association for Hydraulic Research, Vol. 2, Sept., 1967, pp. 103-110 (in English).

Abstract

Sand waves generally occur when bed materials are moved by running water and they present various difficult problems. It is therefore necessary to clarify the hydraulic properties of sand waves in order to solve the problems of the mechanism of sand movement and the resistance law for a movable bed.

Sand waves have two types of characteristics as regards irregularity and periodicity in their shapes and sizes. Statistical treatment is therefore necessary for describing them quantitatively.

In this paper, the authors discussed the statistical properties of sand waves by experimental data obtained using an ultra-sonic sounding device.

In the initial stage of ripples, many waves with different length occur but the small value of the power of the spectrum shows that the bed form in this regime is fairly flat. In typical ripples, one dominant wave develops but the peak is comparable to one at low frequency. In the dune bed, spectral density decreases from the flat peak at a small wave number to the value at a large wave number. In the regime of standing waves, one dominant peak in the spectrum exists the same as the typical ripples. As mentioned above, the spectral density function well represents the characteristics of sand waves for each regime.

The spectral density function can be calculated by the second-order Marcov model when one dominant wave length exists. But in cases where two or more dominant wave lengths exist, the higher-order Marcov model is necessary.

Comparison of the spectral density functions for the process in terms of length and time shows that the propagation velocity of dunes is proportional to the wave length to the $-1/2$ power.

In the dune regime, relative roughness is related to the standard deviation of bed elevation measured from mean bed elevation.

Observation of River Turbulence with an Ultrasonic Flowmeter

By Yasuo ISHIHARA and Shōitirō YOKOSI

Proceedings of the XIth Conference on Hydraulics in Japan,
Feb., 1967, pp. 53-58 (in Japanese).

Abstract

In the development of a new instrument possesing various items for measuring river turbulence, mere improvement of traditional measuring instruments will not be sufficient. Recently, many trial developments have been made on the basis of new principles, and an ultrasonic flowmeter is one of the remarkable instruments developed from them. The principle of the ultrasonic flowmeter is that the time of propagation of sound from a speaker to a microphone depends on the speed of motion of water along this path.

Our instrument is based on the method of sing-around and has three sets of sing-around systems to make simultaneous measurement of two components of velocity perpendicular to each other. This instrument is very convenient for field observation because temperature compensation is unnecessary. Analog out-put is directly indicated to the voltmeter and simultaneouly recorded by the magnetic tape recorder and pen-writing recorder. The pen-writing recorder is usually used as the monitor of the measurement by the tape recorder. The main properties of the instrument are as follows. (i) Both of the components of velocity can be measured in the three ranges: $0\sim\pm1$ m/sec, $0\sim\pm2$ m/sec and $0\sim\pm4$ m/sec. The out-put voltage is $0\sim\pm1$V, $0\sim\pm2$V and $0\sim\pm4$V in each ranges. (ii) The frequency of the sing-around is about 50 KHz and that of the pulse of ultrasonic waves is about 10 MHz. (iii) The separation distance between the speaker and the microphone is 3 cm. (iv) The upper limit of the frequency of the analog out-put is determined by the low-pass filter installed. The cut-off frequency is now fixed at the frequency 100 Hz.

The structure of the vertical turbulence was preliminarily measured by the developed instrument in the river Uji. The data recorded on the magnetic tapes were analized by the analog correlator. The integral time scales in different height are calculated. It was disclosed from the vertical distribution of the cross-correlation between the longitudinal and vertical components of velocity that momentum is transferred towards the water surface in an upper part from the point of maximum mean velocity and towards the bottom in an lower part.

A Study on Flood Forecasting at a Flood Control Reservoir

By Yasuo ISHIHARA and Tadayosi OKUMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 19-31 (in Japanese).

Abstract

As one of the flood-protection works, many reservoirs for flood control have been constructed in Japan. Highly accurate flood forecasting is very strongly desired in order to regulate flood flow efficiently, because of the short delay time between the peaks of storm rainfall and flood runoff. This paper describes the method of flood forecasting based upon the rainfall-runoff relations for each runoff component, after discussing the problems of flood forecasting at such a reservoir.

Most of the reservoirs for flood control are 20~500 Km^2 in catchment area and their storage capacities are 60~250 mm in runoff height. Moreover because of the steep topography, the delay time is of the order of 1~3 hr. Therefore. the method of flood forecasting based upon the usual rainfall-runoff relation seems to be a question of whether it is available for the efficient operation fo flood control.

Flood runoff consists of three components. groundwater runoff, interflow and surface runoff, which show different behavior in the runoff process, respectively. It was disclosed, after separating a flood hydrograph into three components by the use of the new technique proposed here, that the ground water runoff appears late during a flood and scarcely affects the main part of a flood hydrograph, that the interflow is characterized by a so-called simple capacitance-delay process with constant delay process, and that the surface runoff is characterized by a simple capacitance-delay process with constant delay. The practical technique of flood forecasting was presented considering these characteristics, from the viewpoint that such forecasting must be based upon the simple delay time and the deformation of waveform.

It was found as a result that for such a flood-control reservoir the flood forecasting based upon the rainfall observed during the flood is essentially impossible because of the short delay time. Finally, the use of radar for rainfall observation was emphasized in order to forecast flood runoff and to regulate the flood flow, especially at those reservoirs.

Application of Probability Theory in the Design of Flood Control Works in a River System

By Masashi NAGAO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 41-51 (in Japanese).

Abstract

Recently, as one of the flood-protection works, reservoirs have been constructed for the purpose of flood control as well as embankments and retarding pools, which have used before. It is becoming more important to design a program for such a complicated flood protection work in harmony with a whole river system.

To prevent or decrease flood-damages, such various kinds of flood-protection work are constructed with intention to guard the varions districts from the danger of flood. Therefore, it is needed to estimate the exceeding probability of floods to the design criteria of flood-protection works, that is, the probability of chance, where a flood is so enormous that the water flows over any protection work to bring damage. Then, it is not sufficient to use only a peak discharge of flood flow, but it is to be desired to handle the whole figure of the flood itself.

This paper describes the availability of two-dimensional probability theory in estimating the occurrence probabilities of the related factors of flood-figures. First of all, the theoretical method is discussed to estimate the exceeding probabililty of flood-figures by using the two-dimensional probability theory of normal distribution, in cases where a flood-control reservoir exists upstream and an embankment downstream. That is, it is explained that the design of flood-control work should be chosen on a curve of a series of floods with equi-probability density. And it is deduced that in cases of normal distribution by means of the two variables, its curve corresponds to an ellipse, and that by assuming linear transformation of related factors through flood-control operation, the design curve is transformed into an ellipse. Finally, several notations and diagrams available for estimation of the exceeding probability and a computational example of the River Kizu are presented.

As the results of this approach, it is disclosed that the exceeding probability taking account of the correlation among the related factors of flood-figures with the function of flood control becomes considerably different from that of the independent events.

Large Scale Turbulence in a River

By Shōitirō Yoкosı

Annuals, Disaster Prevention Research Institute, Kyoto University,
No.10B, March, 1967, pp. 199-206 (in Japanese).

Abstract

River flow is usually characterized by a large ratio of width to water depth. The depth H and the width B of river flow are of the order of 10^2cm and 10^4cm, respectively, in Japan. On the other hand, the size of the smallest eddies or Kolmogorov microscale η is estimated as being of the order of 10^{-1}cm. Therefore the range of the spectrum of river turbulence in the horizontal direction is $B/\eta=10^5$ and in the vertical direction $H/\eta=10^3$. The relatively large differences between the three values seem to suggest that it is expedient to split the range of the spectrum of river turbulence into three regions: the regions of $\eta\sim$H, H$\sim$B and an intermediate transitional region. If there are no obstacles or no meander in a river channel, in each region, then there exists the socalled inertial subrange, in which no production and no dissipation of energy take place and only energy transfer to smaller and smaller eddies occurs because of a sufficiently large Reynolds number of the river flow.

In the region between η and H in the spectrum of river turbulence, the turbulence is three dimensional and characterized by the vertical scale H, because it is quite similar to that in an ordinary boundary layer. On the other hand, the turbulence in the region between H and B is quasi-two dimensional and characterized by the horizontal scale B. The former would be called 'boundary layer turbulence' or 'vertical turbulence' and the latter 'horizontal turbulence'.

According to the measurements of turbulent velocity in the river Uji and the laboratory flume, the size of the largest eddies of horizontal turbulence, caused not by the artificial or natural variations of a flow discharge but the geomorphological features of a river channel itself, is assumed to be of the order of 10 times the width of the channel longitudinally, and equal to its width laterally and to the depth of the flow vertically. These facts are very interesting for us considering the fact that the length of the largest eddies of the vertical turbulence is of the order of 10 times the depth of flow. When therefore the detailed statistical properties of the largest horizontal eddies are required, observation of the velocity fluctuation over a very long period is needed.

The Spectra of Turbulence in a River Flow

By Yasuo ISHIHARA and Shōitirō YOKOSI

Proceedings of the XIIth Congress of the International Association for Hydraulic Research, Vol. 2, Sept., 1967, pp. 290-297 (in English).

Abstract

This paper describes the results of measurements of the turbulent velocity of a river flow with the ultrasonic flowmeter and the propeller-type current meter. The ultrasonic flowmeter consists of three sets of sing-around systems and makes it possible to measure two components of velocity simultaneously.

The turbulence structure of a river flow is characterized by two different scales: the width of channel B, horizontally and the water depth H, vertically. It seems to be expedient to split the spectrum into two regions, because $B \gg H$ in a river channel generally. The turbulence characterized by B is large in scale horizontally and quasi-two-dimensional. On the other hand, the turbulence by H is as same as that of usual boundary layer turbulence, except in the neighbourhood of the water surface, and three dimensional.

After the analyses of the results of measurements, the followings are obtained. (i) The size of the largest horizontal eddies and the largest boundary layer eddies are about 10B and 10H in a streamwise direction, respectively. (ii) The $-5/3$ power law presented by Kolmogorov with respect to the distribution of energy spectrum density is satisfied in each region. The values of energy dissipation density ε are different: $\varepsilon_H \sim 10^{-2} \mathrm{cm}^2/\mathrm{sec}^3$ for the horizontal turbulence and $\varepsilon_V \sim 10^{-1} \mathrm{cm}^2/\mathrm{sec}^3$ for the boundary layer turbulence. The energy transfer in the region of horizontal turbulence is in the state of a cascade process with ε_H and it is supposed that energy may be transmitted to vertical turbulence through the transitional region by the action of turbulent viscosity defined with ε_H and the water depth. Energy transmitted from horizontal turbulence to vertical turbulence is transformed to smaller and smaller eddies by a cascade process with ε_V and at last, converted by the action of the viscosity ν into heat. (iii) Vertical distribution of cross-correlation between the longitudinal and vertical components of velocity represents that momentum is transfered towards the water surface in an upper part from the point of maximum mean velocity and towards the bottom in an lower part.

Evaluation of Exceeding Probability of Floods for Flood-protection Works in Rivers

By Yasuo ISHIHARA and Masashi NAGAO

Proceedings, The International Hydrology Symposium, Fort Collins, Colorado, U. S. A., Vol. 1, Sept., 1967, pp. 556-564 (in English).

Abstract

There are many factors to be taken account of in designing various water works such as reservoirs and embankments, in which the hydrological quantities become the dominant factors. Customarily, the estimation of the occurrence probability of floods has been made by adopting the peak discharges of floods at a definite point of a river channel as random variables. In order to prevent or decrease the flood-damage happening in correspondence to the various behaviors of a flood phenomenon, the role of guarding various districts from the danger of flood is given to various kinds of flood-protection works. It is, therefore, necessary to estimate the exceeding probability of floods for the design criteria of flood-protection works.

It is not sufficient to use only a peak discharge of flood, but it is to be desired to grasp the whole figure of the flood phenomenon itself. In this paper, the problem of evaluation of the exceeding probability of floods in the whole system of a river is discussed using the joint probability theory in the case where a flood-control reservoir exists upstream and an embankment downstream.

First, the theoretical method is discussed to estimate the exceeding probability of flood-figures by using the two-dimensional probability theory of normal distribution. It is explained that the design of flood-protection works should be chosen on a curve of a series of floods with equi-probability density. It is deduced that in the case of normal distribution with two variables, this curve correponds to an ellipse, and that, by assuming linear transformation of related factors through flood-protection operations, the design curve is transformed into an ellipse. Finlly, several notations and diagrams available for estimation of the exceeding probability and a computational example for the River Kizu are presented.

In conclusion, it is disclosed that the exceeding probability taking account of the correlation among the related factors of flood-figures to the function of flood protection becomes smaller than that of the indendent events.

The Structure of River Turbulence

By Shōitirō Yokosi

Bulletin of the Disaster Prevention Research Institue, Kyoto University,
Vol. 17, Part 2, Oct., 1967, pp. 1-29 (in English).

Abstract

The turbulent velocity of river flow has not been measured accurately because of the lack of a suitable instrument. This paper describes the results of measurements with propeller-type current meters in the river Uji and the Sosui canal.

The turbulence structure of river flow may be characterized by three different scales: width of channel B, horizontally, water depth H, vertically, and furthermore the smallest eddies or Kolmogorov microscale λ_0. It seems to be expedient to split the spectrum into three regions, because $B>H>\lambda_0$ in a river channel generally. The turbulence characterized by B is large in scale horizontally and quasi-two dimensional. On the other hand, the turbulence characterized by H is the same as that of usual boundary layer turbulence except in the neighbourhood of a water surface and is three dimensional.

Interesting results obtained from analyses of observed data are as follows. (1) The energy spectral density is described by the well known 'Kolmogorov $-5/3$ power law' in both horizontal and vertical turbulence. The values of energy dissipation density which is the only parameter determining properties of the inertial subrange are $\varepsilon_H \sim 10^{-2}$ cm^2/sec^3 for horizontal turbulence and $\varepsilon_V \sim 10^{-1}$ cm^2/scc^3 for vertical turbulence. (2) The largest eddies of the horizontal turbulence, caused not by an artificial or natural variation of discharge but by the geomorphological features of the river channel itself, is of the order of 10 times the width of the channel longitudinally, and equal to its width laterally. On the other hand, the length of the largest eddies of the vertical turbulence is about 10 times the depth of flow and the width is about 1/10 times of its length. The size of the smallest eddies or Kolmogorov microscale is a little less than 1 mm and most of the turbulence energy comes to be dissipated in the eddies smaller than those of 1 cm in diameter. (3) In the vertical turbulence, turbulence properties near the bottom are very similar to that of well known wall turbulence. However the intersection region formed between a side wall and free surface or bottom has very complicated properties of turbulence.

On the Mechanism of Laminar Damping of Oscillatory Waves Due to Bottom Friction

By Yuichi IWAGAKI, Yoshito TSUCHIYA and Huoxiong CHEN

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 3, Feb., 1967, pp. 49-75 (in English).

Abstract

The purpose of this paper is to discover the mechanism of the laminar damping of oscillatory waves due to bottom friction with the aid of both the theory of the laminar boundary layer caused by waves and the measurements of the shearing stress and wave amplitude attenuation.

In a theoretical approach, approximate solutions of the laminar boundary layer equations for both the bottom and side walls of a wave tank are obtained by a perturbation method, and the shearing stress on both the bottom and side walls and the rates of wave energy dissipation are calculated. It is concluded that a mass transport velocity exists just outside of the boundary layer on the bottom and that its value is equal to that already obtained by Longuet-Higgins. The influences of the convective terms in the boundary layer equations on the bottom shearing stress and the wave energy dissipation in the boundary layer on the bottom are also considered. On the other hand, a theory of the laminar damping of Airy waves is established.

In experimental studies, direct measurements of instantaneous shearing stresses on the bottom were made with a shear meter, and some observations of wave amplitude attenuation were performed. It is concluded from both the results of the theory and the experiments that the influence of the convective terms on the bottom shearing stress are generally negligible within the range of the experiments, but that those on the side wall of a wave tank are considerable; accordingly the experimental values of the bottom shearing stress agree well with the result of the linearized theory. With regard to wave damping, it is concluded that the experimental values of the wave decay modulus are approximately 30% larger than the theoretical ones. It would seem that the discrepancy is due to the existence of some other energy dissipations.

Hydraulic Model Experiment on Behaviour of Storm Surges in Rivers and Canals in Osaka City —Additional Change of Storm Surges due to Construction of New Storm Surge Prevention Gates—

By Yuichi IWAGAKI, Shigehisa NAKAMURA and Huoxiong CHEN

Annuals, Disaster Prevention Research Institute,, Kyoto University, No. 10B, March, 1967, pp. 207-222 (in Japanese).

Abstract

Construction of five storm surge gates, to prevent storm surges running up the rivers and canals in Osaka City, were planned a year ago in order to protect the City from the disaster of innundation. However there is the problem of water piling-up by storm surges on the downstream side of the gates. This study is designed to give a reasonable and qualitative estimation of the effects of gate operation.

A 1/100 vertical and 1/500 horizontal scale model of the rivers and canals in Osaka City was constructed. A storm surge generator of plunger type is driven by an induction motor of 3 H.P. The plunger is 5 m long and has a triangular cross section (116.7 cm wide and 70 cm high), to which two pumps of 3 H.P. each and a syphon system (18 cm in diameter) are connected to move water in and out of the plunger alternatively when producing storm surges. It is possible to produce storm surges over a range up to model heights of 2.6 cm over a duration time of 1.5 to 15 minutes.

At first, reproductivity of past storm surges was successfully tested in the hydraulic model. The effect of the storm surge gates on water piling-up by storm surges was investigated in the model. The result of the model experiments proved that the height of piling-up by storm surges will be increased by as much as 30 cm by the operation of the gates.

The height of the peaks does not increase uniformly from the river mouths to the location of the gates. The irregular increase is believed to be due to topographical effects, seiches in the rivers and mutual interaction of undulations in the rivers and canals.

Some Experiments on the Closing of a Model River Mouth due to Wave Action

By Hideaki NODA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 223-233 (in Japanese).

Abstract

It has been observed in many rivers that sand bars are formed in river mouths and consequently cause shoaling and finally closing by drifing sand carried in from shore supply sources, when the tractive force of incident waves predoninates over that of the river current. This problem is very important in navigation and drainage; however, a basis for predicting the closure of river mouths has not been established as yet, because of the difficulties in understanding the mechanics of sediment transport in relation to shoaling materials under prevailing conditions of river flow and wave action.

In this paper, as an approach to discovering the main factors which govern the formation of a sand bar and closing of a river mouth, two dimensional model experiments were performed using a simple model of a river mouth.

The effects of various elements in shoaling, such as wave and sediment characteristics and depth of the river mouth on the quantity of deposits and the equilibrium profiles of the bar formed at the river mouth due to wave action are discussed on the basis of some experimental results.

The conclusions derived from the experimental results are as follows:

(1) Topography near the river mouth is classified into three types; erosion type, transition type and deposition type. With the exception of the erosion type, the sand bar is formed and is an important element in shoaling under wave action alone.

(2) The criterion for generation of the bar is determined by the steepness of deep water waves, the ratio of the sediment diameter to the deep water wave height and the ratio of the depth of the river mouth to the wave height.

(3) The ratio of the depth of the river mouth to the wave height is a very significant factor in determining the quantity of deposits in a river mouth.

In addition, an attempt at predicting the rate of transport of shoaling sediment due to wave action is made to determine the equilibrium profile of the bar, but satisfactory results were not obtained.

Facilities and Equipment of the Ōgata Wave Observatory and Some Results of Wave Observations

By Yuichi IWAGAKI, Haruo HIGUCHI, Hideaki NODA and Tadao KAKINUMA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10B, March, 1967, pp. 237–250 (in Japanese).

Abstract

On 24 November 1966 the Ōgata Wave Observatory was opened in order to observe the transformation of coastal waves in shallow water, the nearshore current system, sand drift, and variation of bottom configuration, etc.

In this paper, the facilities and equipment installed are described with some results of wave observations. At the Ōgata Observatory, located at 37° 13′ N, 138° 19′ E, there is a pier and tower belonging to the Teikoku Oil Company, Ltd. The pier extends in the direction NNW, the total length is 314.5 m, and the water depth at the end is about 7 m. The tower is located at a depth of 15 m and 2.2 km from the pier in the direction NNE. The diameter of the steel piles of both structures is 565 mm in the neighborhood of the sea surface.

Six step-resistance type wave gauges are installed on the pier and three at the end have a triangular array in order to measure the direction of waves. One step-resistance type wave gauge is installed on the tower. The ranges of the wave gauges on the pier and the tower are 7 m and 14 m, respectively, and the interval between the electrodes of all the wave gauges is 5 cm in the neighborhood of the sea surface.

Using a digital tracer OT-50, pen and ink records were either digitized at 0.5 second intervals or converted to magnetic tapes. The wave energy spectra were obtained from the wave data using both the digital computer KDC-1 at Kyoto University and the spectrum analyzer.

The motion of the sea surface at the piles was photographed by two 16 mm cine-cameras with telephoto lenses at a film speed of 2 frames per second for 15-minute periods. The vertical displacements of the sea surface at the piles were read out through the "NAC" motion analyzer and the wave energy spectra were obtained using the spectrum analyzer.

On Wave Observation off Hiezu Coast and Takahama Coast

By Tadao KAKINUMA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 251–272 (in Japanese).

Abstract

Forecasting shallow water ocean waves is one of the most important problems in coastal engineering at present. Nevertheless among the characteristics of shallow water ocean waves, the wave height reduction due to bottom friction is not well known.

To clarify the transformation of relatively large shallow water ocean waves, wave observations were made off the Hiezu coast in 1964 and the Takahama coast in 1965.

This paper presents the results of wave observations analyzed both by the significant wave and the wave spectrum method.

During wave observations off both coasts, two buoys were set in position about 600 m apart in the direction of the incoming waves. The two buoys in wave motion were photographed by two 16 mm cine-cameras with telephoto lenses at a film speed of 2 frames per second for 15-minute periods.

At the Hiezu coast, two buoys were set at depths of 13.5 m and 9.8 m, respectively, and the bottom ripples were measured by Inman's method at four stations on the fifth day after the wave observations.

At the Takahama coast, two buoys were set at depths of 9.8 m and 6.3 m, respectively, and the bottom sediment was sampled.

The wave energy spectra in shallow water obtained off both coasts are expressed by Kf^{-n}, where the values of n are between 3 and 5 at high frequencies.

Nine and twelve individual 15 minute sets of wave data were obtained at the Hiezu coast and the Takahama coast, respectively. From these data the transformations of ocean wave spectra in shallow water, which are very important in clarifying the energy transmission in shallow water, are obtained.

Experimental Study of Wave Pressure Acting on an Arch Gate (First Report)

By Yuichi IWAGAKI, Masao INOUE and Masahiro YOSHIKAWA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10 B, March, 1967, pp. 273-281 (in Japanese).

Abstract

In order to prevent disaster caused by storm surges, an arch gate is being constructed in the estuary of the Aji River by the Osaka Prefectural Government.

In this paper, the results of model experiments of wave pressure acting on the arch gate are described. The experiments were carried out using a 1/20 scale model with a concrete wave tank 20 m long, 3 m wide and 0.7 m deep. The waves used in these experiments were uniform waves. The characteristics of the waves were 1.0, 1.2, 1.4 and 1.6 sec in period and from 2 to 12 cm in height. For each period, water depths of 40, 45 and 50 cm were used.

The main results obtained from the experiments are summarized as follows:

1) The maximum wave pressure, measured at still water level, varies greatly with the period of the incident waves. The maximum wave pressure is located at the center of the arch gate for all periods of incident waves tested. The location of minimum pressure moves along the gate with changes in wave period.

2) The Sainflou formula can not be applied to calculate the vertical distribution of maximum wave pressure when using the height of incident waves as measured in the experiment.

3) In order to solve the problem of wave pressure on a structure with a curved surface, the mechanism of water surface oscillation in front of the structure will have to be understood.

Studies on Cnoidal Waves (Fourth Report) —On Hyperbolic Waves (1)—

By Yuichi IWAGAKI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 283-294 (in Japanese).

Abstract

It is very difficult for engineers to deal with the cnoidal wave theory for the purpose of practical application, since the cnoidal wave theory contains the Jacobian elliptic functions, their modulus k, and the complete elliptic integrals of the first and second kinds $\boldsymbol{K}$ and $\boldsymbol{E}$ respectively. This paper proposes formulas for various wave characteristics of new waves named "hyperbolic waves", which are derived from the cnoidal wave theory on condition that $k\approx 1$ and $\boldsymbol{E}\approx 1$ but $\boldsymbol{K}$ is not infinite and a function of $T\sqrt{g/h}$ and H/h (T : the wave period, h : the water depth and H : the wave height), so that cnoidal waves can be approximately expressed by primary functions only. The new waves named "hyperbolic waves" are, in other words, intermediate between cnoidal and solitary waves, because the solitary wave theory can be derived by putting $k=1$, $\boldsymbol{E}=1$ and $\boldsymbol{K}=\infty$ in the cnoidal wave theory.

Formulas for the wave characteristics of hyperbolic waves derived in the present paper include those of the height of still water level above the wave trough, wave profile, wave velocity, wave length, water pressure, water particle velocity, wave energy and its transmission. In addition, a limiting condition for application of the hyperbolic wave theory is presented.

Some Contributions to Hydraulic Model Experiments in Coastal Engineering

By Shoitiro HAYAMI, Tojiro ISHIHARA and Yuichi IWAGAKI

Proceedings of the 10th Conference on Coastal Engineering,
Vol. II, Part 4, Sept., 1966, pp. 1291–1312, (in English).

Abstract

This paper presents some aspects of the hydraulic model experiments in coastal engineering made at the Ujigawa Hydraulic Laboratory, Disaster Prevention Research Institute, Kyoto University. Included are experiments performed by using an estuary model basin and a high speed wind wave channel. In particular, the problems to which attention should be paid from the view point of similitude between model and prototype are discussed in addition to the presentation of experimental results.

Experiments in the estuary model basin described in the present paper consist of model tests of Hiroshima Bay for tidal flow pattern, Sakai Channel for frequency response of sea level oscillation and Nagoya Harbor for tidal flow pattern, current velocity at the opening of the new breakwater and frequency response of sea level oscillation and its non-linear effect. It is especially pointed out by the model test of Nagoya Harbor that it is necessary to know the present value of the discharge coefficient at the opening in the prototype if the future maximum current velocity at the opening in the prototype is to be estimated from the experimental data obtained in the model.

From the experiment on waves overtopping seawalls in the wind wave channel it is shown that the effect of wind on wave overtopping differs greatly with changing characteristics of the incident waves. Wave characteristics therefore cannot be ignored in a case where the water depth at the toe of the seawall is large compared with the incident wave height.

On the Mechanism of the Local Scour from Flows Downstream of an Outlet

By Yoshito TSUCHIYA and Yuichi IWAGAKI

Proceedings of the 12th Congress of the International Association for Hydraulic Research, Sept., 1967, pp. C-7-1-10 (in English).

Abstract

This paper describes an approach for establishing the mechanics of local scour, based on some experimental results on the local scour downstream of an outlet. A series of basic experiments on local scour were carried out by using two different experimental water tanks and sediment of eight different sizes. With respect to the variations in maximum depth of scour with time, it was found that there are three stages in the phenomenon of scour: the first is the initial one where the depth of scour changes linearly with time, the second is the transition from the initial to the progressive stage, and the third is the progressive stage of the development of scour, where the variations in the maximum depth are due both to the characteristics of wall jets and rollers developing in a scour hole.

In the first part of the paper, the mechanism of local scour for the initial stage of development of scour is considered, based on characteristics of wall jets and an approach to nonequilibrium sediment transport. It is verified from both theory and experiment that the theoretical relationships of the configuration of a scour hole, the distribution of the rate of sediment transport along the scour hole and the change in the maximum depth of scour are in good agreement with the experimental results.

In the second part, an approach for discovering the mechanism of local scour for the progressive stage is described. Distribution of the rate of sediment transport along the scour hole is calculated with the aid of the similitude in the configuration of scour holes and the equation of continuity for scour. An expression of the modified equation of continuity is established to discover the mechanism, based on sediment transport theory and the characteristics of rollers developing in a scour hole. An example is given to show the applicability of this approach.

On the Shoaling of Finite Amplitude Waves

By Yuichi IWAGAKI and Tetsuo SAKAI

Proceedings of the 14th Conference on Coastal Engineering
in Japan, Oct., 1967, pp. 1-7 (in Japanese).

Abstract

This paper deals with the theoretical study of wave shoaling. In the region where the ratio of water depth to wave length is small, the existing experimental results show that when waves proceed into shallow water from deep water, the rate of increase in wave height is greater than that proposed by the small amplitude wave theory. To explain this phenomenon, the authors calculate the equation of energy transmission of hyperbolic waves derived from the cnoidal wave theory when the complete elliptic integral of the first kind K is greater than 3 and give the theoretical curve of change in the wave height.

This curve is compared with the theoretical curves based on Stokes' wave theory and small amplitude wave theory, and with the existing experimental results. Conclusions are as follows.

1) The theoretical curve of change in wave height based on formulas of hyperbolic waves gives the same tendency as that based on Stokes' wave theory.

2) This curve explains the fact that when the waves proceed into shallow water from deep water, the rate of increase in wave height is greater than that proposed by the small amplitude wave theory in the region where the ratio of water depth to wave length is small.

3) Some differences are found between the existing experimental results and a more exact experimental study of this problem is necessary.

Limiting Conditions for Application of Stokes and Cnoidal Wave Theories

By Yuichi IWAGAKI and Masataka YAMAGUCHI

Proceedings of the 14th Conference on Coastal Engineering in Japan, Oct., 1967, pp. 8-16 (in Japanese).

Abstract

Stokes wave theory can not be applied to finite amplitude waves because of the divergence of series expansions when the wave steepness becomes large and the ratio of water depth to wave length becomes small. On the other hand, there must exist a limiting condition for application of the cnoidal wave theory, which is not suitable for the case of large values of the water depth-wave length ratio, because the theoretical solution of the cnoidal wave theory is derived on condition that the water depth-wave length ratio is small.

In this paper, limiting conditions for application of both Stokes and the cnoidal wave theories are discussed after showing, by a comparison of the wave velocity formulas of Sato, Tanaka and Skjelbreia, that the third order approximate solutions by Skjelbreia are the best available to use in Stokes wave theory. The method used here to find the limiting conditions for both wave theories is a comparison between precise experimental measurements of wave velocity and crest height above still water level and the predictions based on the cnoidal and Stokes wave theory.

As a result, it is found that applicable ranges for the cnoidal wave theory are $T\sqrt{g/h}\geq 12$ when $3\leq h/H\leq 5$ and $T\sqrt{g/h}\geq 6$ when $10\leq h/H$, and that those for Stokes wave theory are $T\sqrt{g/h}\leq 10$ when $3\leq h/H\leq 5$ and $T\sqrt{g/h}\leq 20$ when $10\leq h/H$, in which T is the wave period, h the water depth and H the wave height.

An Experiment on the Behaviour of Storm Surges in Rivers and Canals in Osaka City

By Yuichi IWAGAKI and Shigehisa NAKAMURA

Proceedings of the 14th Conference on Coastal Engineering in Japan, Oct., 1967, pp. 104–113 (in Japanese).

Abstract

Construction of five storm surge gates, which will prevent storm surges running up rivers and canals in Osaka City, were planned a year ago in order to protect the City from the disaster of innundation. However, there remains the problem of water piling-up by storm surges on the downstream side of the gates. In this paper, a reasonable and qualitative estimation was given with consideration of the peak height, time change of water level and currents due to storm surges by use of a hydraulic model (in scale of 1/100 vertical and 1/500 horizontal). The storm surge generator used in this model, of plunger type, produces storm surges over a range up to model height of 2.6 cm during the 1.5 to 15 min period or duration time of storm surge.

At first, reproductivity of the past storm surges was tested in the hydraulic model. Duplication was proved to be more successful when the wave form is similar to the actual records of entering storm surges. After this test, the effect of the gates on water piling-up by storm surges was investigated in the hydraulic model. The results of the model experiments proved that the peaks of the storm surges will be increased as much as 30 cm by construction of the storm surge prevention gates. The height of the peaks does not increase uniformly from the river mouths to the location of the gates. The irregularities might be caused by topographical effect, seiches in the rivers and mutual interactions of undulations in the rivers and canals. These effects are also discussed from the viewpoint of the deformation of storm surges. To investigate the deformation of the storm surge, the wave forms were expanded into a Fourier series. The deformation was estimated through propagation of the storm surge in rivers before and after construction of the gates. To measure the currents, paths of floats were obtained by photographic tracking and their time derivatives were calculated near the river mouths and at the locations of the gates. The study suggests that currents might contribute to the maximum amount of water piling-up outside the gates due to the entering storm surges.

Experiments on Wave Pressure Acting on an Arch Gate

By Yuichi IWAGAKI, Masao INOUE and Masahiro YOSHIKAWA

Proceedings of the 14th Conference on Coastal Engineering
in Japan, Oct., 1967, pp. 139–147 (in Japanese).

Abstract

The experiments of wave pressure acting on the arch gate now under construction by the Osaka Prefectural Government were carried out using a 1/20 scale model. Consequently, it was concluded that the mechanism of water surface oscillation in front of the arch gate had to be understood to solve the problem of the wave pressure acting on it. With this in view, the experiments on water surface oscillation in front of the gate were carried out using a wave tank 20 m long, 3 m wide, and 0.7 m deep. The waves used in these experiments were uniform and short crested waves.

In this paper the relations between characteristics of the water surface oscillation in front of the gate and those of incident waves are described on the basis of the experimental results. It is of especial interest that the distribution of wave height in front of the gate varied with the period of the incident waves. In addition, a theoretical approach to disclose the mechanism of the water surface oscillation in front of the gate is presented by applying Goda's theoretical solution of resonance in a fan-shaped harbor. However, the experiments did not agree with the theory,except in the case where the period of the incident wave was 1.4 seconds.

With regard to the wave pressure, the horizontal and vertical distribution of the maximum wave pressure was measured for uniform and short crested waves.

It is seen from these considerations that the horizontal distribution of maximum wave pressure depends almost entirely on the wave height in front of the gate. For the vertical distribution of maximum wave pressure, there is good agreement between experiment and theory for small amplitude waves, for finite amplitude waves of the second approximation by Kishi, and for the Sainflou formula, using a half wave height in front of the gate instead of the height of the incident wave measured 6 m from the gate.

Suspended Sediment due to Wave Action

By Hideaki NODA

Proceedings of the 14th Conference on Coastal Engineering
in Japan, Oct., 1967, pp. 306-314 (in Japanese).

Abstract

This paper deals with the mechanics of sediment suspension by wave action. In the case of sediment movement in the littoral zone, which is mainly in the form of suspended load, the relationship between hydraulic conditions, such as wave characteristics, water depth, etc. and concentration of suspended sediment has not yet been established.

In the first present paper, the vertical distribution of suspended sediment, obtained from both laboratory (by standing waves) and field (by irregular waves) investigations, is discussed on the basis of the fundamental equation of sediment suspension by wave action. The vertical distribution is also used in estimating a mixing coefficient. It is shown that a value of the mixing coefficient estimated from the observation results is of the order of $10^2 cm^2/sec$, while that of the experimental ones is of the order of $1 cm^2/sec$. In addition, a few comparisons of measured and theoretical values of the mixing coefficient show that the former is not in agreement with the latter, and that the mixing coefficient depends on whether the sea bottom is smooth or rough.

In the second part, the relationship between the sample volume obtained by the bamboo-sampler and the instantaneous concentration of suspended sediment is discussed. The sample volume of the bamboo-sampler is approximately in proportion to the concentration of suspended sediment, and the proportional constant seems mainly to depend upon the wave and sediment characteristics and the dimensions of the bamboo-sampler.

On the Change of Salinity Distributions after the Closing of a River Mouth (Part II)

By Hideaki KUNISHI and Toru SUZUKI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 513-522 (in Japanese).

Abstract

The salinity distribution downstream from a sluice gate constructed in an estuarine part of a river to prevent the upstream intrusion of the sea water has been studied in a test flume.

The test flume consists of a sea part of the dimension of 3 m × 3 m × 0.5 m and a river part of the dimension of 7 m × 0.5 m × 0.5 m, and a model sluice gate has been set in the middle of the river part. The experiment has been carried out for several combinations of hydraulic conditions (fresh water discharge, density difference between fresh water and saline water, head difference at the sluice gate) and the position of the discharging mouth of the gate. The tidal condition has been neglected. The discharging mouth of the sluice gate has been as wide as one fifth of the flume width. The salinity distribution has been measured by electric conductivity and the flow pattern has been observed by the dye tracing method.

The flow shows a stratified two layer system and the inflow of the fresh water fallen from the gate makes a mixing region near the bottom of the downstream side of the discharging mouth, into which saline water intrudes and entrains into the upper layer. The salinity distribution in the upper layer is almost uniform laterally and longitudinally excepting the region near the gate.

This seems to mean that the salinity concentration of the upper layer downstream from the gate is determined mainly by the entry mixing occurring in the mixing region near the gate, and that although there are unstable internal waves at the interface, the effect of that process on salinity distribution is of minor importance. The result of experiments shows that the salinity concentration in the upper layer decreases when the fresh water discharge increases. The mechanism controlling the entry mixing remains obscure.

On the Behavior of Water Temperature Observed at Shirahama Oceanographic Tower Station (II)

By Hideaki KUNISHI, Katsuya NISHI and Yuki YUSA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 295-303 (in Japanese).

Abstract

There are some interesting variations with time in the records of water temperature which have been observed since 1962 at the Shirahama Oceaographic Tower Station. They are classified into several types of variation.

The variations named type S and type R have a period of 30-40 minutes. Type S is an oscillation of sinusoidal form with an amplitude of 0.1°C to 0.2°C and it continues for 4 to 5 hours. Type R is a variation having a slightly irregular rectangular wave form with an amplitude of about 1°C, and it lasts for several hours to one day. These types seem to be related to the oscillation of water level which is on the the tidal curve.

The variation with a period of from 3 or 5 to 15 or 18 hours named type T seems to have some relation to the tide, though it is not so clear.

The diurnal change of water temperature is found to be 0.35°C in autumn and to be 0.69°C in summer near the surface, and to be 0.31°C in autumn and to be 0.51°C in summer near the bottom of 5 m depth. These values are rather small compared to the values ordinarily found in coastal areas. It seems to mean that the location of the Tower Station has a considerably open oceanic character. The rather small values of these changes are ascribed to the rather large value, about 300 cm^2/s, of vertical eddy diffusivity found from the above-mentioned values of the diurnal changes of water temperature.

In the first report we have discussed the net shifs in water temperature caused by the passage of the thermal front, and have supposed that the net shifts in water temperature would be an index showing the exchange of waters inside and outside of the bay. In this report we discuss some additonal explanations of how this phenomenon comes about.

The daily mean water temperature shows the fluctuations with a period of several or ten and some odd days. These fluctuations are considered to be connected with the above-mentioned net shifts of water temperature.

Some Observations on the Coastal Processes in Tanabe Bay

By Hideaki KUNISHI, Katsuya NISHI and Toru SUZUKI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 305-311 (in Japanese).

Abstract

The continuous records of sea water temperature in shallow water of 5 m depth at the Shirahama Oceanographic Tower Station, which is located near the mouth of Tanabe Bay, show a quick shift of more than 0.5 °C, 3 °C at the extreme, in sea water temperature within ten or so minutes or several tens of minutes, and the histogram of its occurrence interval has peaks at 3 or 4 days and at 7 or 8 days (Kunishi, Nishi and Yusa, 1965). Kunishi et al have considered that this phenomenon would be the passage of a thermal front through the Tower Station and that it would mean the occurrence of an exchange of waters inside and outside the bay. A project for investigating the time variations of distributions of water temperture and salinity is in progress in Tanabe Bay. In this paper an analysis of the two observations held until now is presented.

In the first survey in August, 1964, a thermister thermometer was towed once a day in the layer of 2m depth along the survey line in the bay (5 km × 5 km × 20 m) in order to find out whether the quick shift could be ascribed to the passage of a thermal front. During the survey period a quick shift in the water temperature had been recorded at the Tower Station, and this quick shift seemed to be related with the passage of a thermal front through the Tower Station. In the second survey in November, 1965, a thermister thermometer and a salinometer were used at oceanographic staions, and the observation was carried out once a day for three days. During the survey period no quick shift was recorded and no thermal front was observed. The vertical distributions of temperature, however, reveal that a temperature inversion along the bottom occurred during the last day. The change of pattern of the T-S diagrams shows that a large scale convective flow occurred that day and the motion approached its end during the survey period. It is considered that the motion was induced by the horizontal density difference due to precipitation.

Study of Waves at Shirahama Oceanographic Tower Station (II)

By Hideaki KUNISHI, Katsuya NISHI and Norihisa IMASATO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 313-320 (in Japanese).

Abstract

We have studied the structure of the wave-field accompanying a typhoon by calculating the power spectra of wave records obtained at the Shirahama Oceanographic Tower Station. In the first paper of the same title, we have mentioned that the waves coming from the region of typhoon 6420 include two sharp frequency bands, and that the position of the first peak seems to depend on the value of the central pressure of the typhoon. These points are examined using the 38 records of waves caused by typhoons 6309, 6313, 6314, 6523 and 6420.

Energy spectra of these wave records show the two peak structure as mentioned in the first paper, and its periods are about 14 sec and 7 sec.

Assuming that the energy of waves observed at the Tower Station is transported from near the center of typhoon with the group velocity, the wave period of the first peak of energy spectra T(sec) increases logarithmically with the central pressure of the typhoon P(mb), and its relationship is expressed as

$$T = 467.7 - 152.9 \log P.$$

This wave period should be expected to have some relation with the maximum wind speed of the typhoon. Using the empirical law which gives the relation between the central pressure of a hurricane and the maximum wind speed in the storm area of a hurricane, the wave period T(sec) of the first peak of energy spectra increses linearly with the maximum wind speed U(m/sec) in the storm area of the typhoon and is expressed as

$$T = 0.148\,U + 5.59.$$

In order to establish the relationships mentioned above, it is necessary to estimate the period of first peak of energy spectra more accurately, and the origin of the waves which make the second peak of about 7 sec of energy spectra is left as an open question.

Observation of Water Circulation in Lake Biwa-ko

By Hideaki KUNISHI, Iwao OKAMOTO and Hideo SATO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 321–329 (in Japanese).

Abstract

In order to test the applicability of the "bathythermograph" instrument to the study of water circulation in Lake Biwa-ko, the first trial observation was held on 29 th August 1966, using this instrument for measuring the vertical distributions of water temperature at about sixty hydrological stations covering the whole of Northern Lake Biwa-ko.

To analyse the data, we have adopted the oceanographer's dynamic height method assuming that the 30 meter-layer is the no-current one. This is based upon the fact that the standard deviation of water temperature below the depth of 35 meters takes a constant value of about 0.2°C. The flow pattern of the 2 meter-layer obtained, shows a clear anticlockwise circulation and its velocity is estimated as about 20 cm/sec. This is the first circulation in Lake Biwa-ko and it has long been known as the most conspicuous summer current pattern in the lake.

The computations of water transport, however, across the vertical cross section along each lateral survey line do not bring about reasonable results. At survey line-III, for instance, the surplus of northward water transport up to about 13,000 ton/sec occurs. Such a volume transport seems too large to explain as water transport accompanied with internal waves. It is not considered to be adequate to assume the 30 meter-layer as the no-current one. To resolve this contradiction it is good enough to take the no-current layer not at a depth of 30 meters but at the depth of the center of jumping layer of water temperature which is about 17 meters in this season.

Then, it can be considered that there is large scale vertical circulation, from south to north in the upper layer and from north to south in the lower layer. This may be a density current which has occurred due to the horizontal difference of water density. The average water temperature on the cross section along each lateral survey line is lower northwards and higher southwards. Reasonable determination of the no-current layer is one of the most important problems for the future.

The Subsoil and Ground-Water Investigations Surrounding Lake Biwa

By Koichi AKAI and Takao UNO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10-B, March, 1967, pp. 391–406 (in Japanese);
Journal of JSCE, Vol. 52, No. 4, April, 1967, pp. 24–30 (in Japanese).

Abstract

A series of geological and hydraulic investigations on the ground-water problems in the inland region around Lake Biwa derived from the new development planning for utilizing the water resources of the lake are treated. Subsoil conditions and characteristics of the ground-water surrounding the lake were investigated in detail through field reconnaissances and field tests performed in the representative regions. Next the aquifer constants in each region were determined by the field drawdown tests and other analytical tests. Regarding the permeability of the surface layers, which has an essential influence on the ground-water behaviour at the water table depression in the lake, two kinds of special field observation of ground-water by means of the wave propagation theory were adopted. Thus for each region investigated, we know reliable values for thickness of aquifers H_0, transmissibility coefficient T, coefficient of permeability k, storage coefficient S (=effective porosity β in the unconfined condition), compressibility of aquifers σ and the ratios k/β or k/σ. Generally speaking, the aquifer constants at the western side of Lake Biwa indicate pretty large values, reflecting the sedimentation condition of ground where coarse gravel and stone transported by the river with a steep slope are predominant.

Variation in the observed ground-water surface with the descent of the water level in the lake was analyzed from past data. In addition the movement characteristics of ground-water surrounding the lake were assumed from the viewpoint of the constitution of strata. Then giving the flow conditions at the upstream boundaries of each river area, we calculated the water-table depression in the inland region accompanied with the variation in the water level of the lake which may be expected to be as low as 3 meters. In the calculation the fundamental differential equation of heat conduction type was transformed into a finite differential equation and solved by means of the computer. The solution varies somewhat widely due to the characteristics of the ground-water flow and the sedimentation condition of soil strata in each region. The results of investigation indicate that the so-called influenced region can be estimated to be about 3–5 km from the shore on the eastern side of the lake, while it is as far as about 2 km on the western side.

On the Compression and Shear Character of Sand

By Norio YAGI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 375-381 (in Japanese).

Abstract

The stress-strain curve of sand is necessary for the calculation of the settlement of the sand layer when stress condition in the layer undergoes a change. In this paper the results obtained from laterally confined compression test and triaxial extension test for Japanese standard sand are presented and discussed. The conditions of the sample in former test are as follows; initial void ratio e_i is maximum void ratio e_{max} (0.960), (2) $e_i=0.920$, compacted by vibration (3) $e_i=0.940$, precompressed by static load (4) $e_i=e_{max}$, repetitional compression.

From these test results, it is found that the amount of the settlement in the case of compaction by vibration is lager than that in the case of compaction by static load in the same initial void ratio and at the same vertical stress and that the amount of the settlement is increased by repetitional compression. The settlement is considered to resolve into the reversible part due to the elastic deformation of sand grains and the irreversible part due to the sliding between sand grains.

On the other hand, the triaxial extention test is carried out under conditions where the mean principal stress σ_m was kept constant while the deviator stress increased. From this test, the volume change due to dilatancy in the extension state is obtained and is compared with that in the compression state.

Seepage from a Canal into Soil with Shallow Water Depth

By Koichi AKAI and Takao UNO

Proceedings of the 3rd Asian Regional Conference on Soil Mechanics and Foundation Engineering, Vol. 1, Sept., 1967, pp. 131-134 (in English).

Abstract

Previous studies of seepage from a canal into soil were concerned with estimating the rate of recharge, so that the relationship between the latter and the shape of the free water surface was not sufficiently clarified. In practice the ground-water level near a lake, whose own water level is falling, may be controlled by seepage flow from a nearby canal. In the present research the free water surface formed by this seepage is studied for soil with shallow water depth, and results are compared with two-dimensional seepage experiments in a sand model.

The composite flow system is analyzed with the aid of the ω-plane ($\omega=\varphi+i\psi$) and it is transformed onto the ζ-half-plane. Thus the ordinate of the characteristic point of the system is analytically expressed, the rate of recharge into the canal being obtained at the same time.

As the experimental apparatus a rectangular sand mass ($23\times45\times315$ cm) with fine uniform sand was placed in a steel flume with a glass front. The water level on both sides of the sand model was arbitrarily controlled. Groundwater from the upstream reservoir q_E with depth H_E was discharged into the downstream one. The free surface was observed at steady state under q_E only, after which the free surface and the water head were measured by piezometer under both q_E and the recharge into the canal q_O. Two condition variants were considered for the upstream boundary: constant q_E and constant H_E. The seepage pattern was traced with the aid of green Uranine dye, which forms a smooth concave curve under the canal, a so-called "water-curtain" beyond which the seepage does not spread. The spread of the water-curtain increases with q_O.

With constant q_E, the rise of the upstream free surface at the steady state is nearly proportional to q_O and becomes constant independently of the distance x from the canal. With constant H_E, on the other hand, the rise of groundwater remains proportional to q_O but decreases exponentially with x. It is seen that the dependence of kh/q_O on x is little affected by the shape of canal and the gradient of free surface.

In closing it can be said that, for both upstream conditions, the upstream rise of the free water level is nearly proportional to the rate of recharge, owing to the water-curtain formed under the canal.

On the Safety Factor in the Stability Analysis of Sliding Failure

By Koichi AKAI

Proceedings of the 12th Soil Engineering Symposium, Sept., 1967, pp. 25–30 (in Japanese).

Abstract

A comparison of the safety factors obtained by total stress analysis ($\varphi=0$-analysis) and effective stress analysis (c, φ-analysis) is performed at the beginning of the present investigation. Total stress analysis can be applied in a case where the stress condition in the field is in accordance with that of undrained tests in the laboratory. Thus it is said to be "the end of construction method". The manner of variation in the safety factor after the completion of structures depends upon the magnitude and the sign of stress changes. In effective stress analysis, on the other hand, we have to assume the distribution of pore pressure along the potential sliding surface. This method is called "the long-term stability method". The correlations between these two methods are investigated by a simple exercise. The result shows that we obtain different safety factors F with each, except for the limiting case of $F=1$.

Variations in the safety factor due to the slight change of shear strength parameters are checked numerically using the result of stability analyses of a natural slope in quick clay. Combining the results of borings, samplings, in situ tests and pore pressure measurements in the field, together with those of laboratory tests, it is concluded that a composed slide surface should be used, instead of a simple circular one. As the cause of the slide it is assumed that a considerable amount of excess pore pressure in the clay layer might contribute to the occurrence of the slide. Calculating the safety factor F for some combinations of the shear strength parameters c' and φ', it is found that a slight variation in estimating the cohesive strength c' has a remarkable influence on the value of F.

In addition, the mechanism of progressive failure along the sliding plane is investigated. In this research a concept of residual shear resistance is introduced and the stability of an earth-filled dam constructed in a lake is analysed. It is found from this calculation that there exists some possibility of the occurrence of local failure in the deep part of the slide circle, the other parts remaining to a great extent in their non-plastic states. The result is qualitatively confirmed by the model experiment.

Study on the Failure Mechanism of Sandstone under Compressive Stresses

By Koichi AKAI and Hiroaki MORI

Transactions of JSCE, No. 147, Nov., 1967, pp. 11-24 (in Japanese).

Abstract

A newly designed triaxial testing machine was used to investigate the ultimate strength of sandstone specimens under uni-, di- and tri-axial stress respectively, as well as the failure pattern of the rock material. The size of the specimen is 5 cm cube and the capacity of the testing machine is 200 tons vertically and 100 tons at each horizontal axis. Experiments were carried out under stress-controlled conditions (8 tons/min). Rubber sheets with silicon-grease are always used to minimize friction between the specimen and piston plates; thus the friction coefficient could be reduced to 0.002.

Unconfined compressive strength of the rock material was found to be $\sigma_c = 1190\ \mathrm{kg/cm^2}$ with a variation of about $\pm 3.9\%$. For the sake of non-dimensional representation of di-axial and tri-axial test data, all results are expressed as the value divided by σ_c. Representing the test record on $\sigma_1 - \sigma_2$ plane, it seems to be of interest that the same results are obtained by the axial compression test ($\sigma_1 > \sigma_2 = \sigma_3$) and the axial extension test ($\sigma_1 = \sigma_2 > \sigma_3$) for any value of σ_3. Introducing the principal stress parameter λ, $\tau_m/\sigma_c - \sigma_m/\sigma_c$ relationship shows that the experimental results of the axial compression test ($\lambda = -1$) with high confined stress are in accordance with Mohr-Coulomb's failure criterion ($\varphi_0 = 33°40'$, $c_0/\sigma_c = 0.46$). Under low confined stress, however, experimental results deviate from the above criterion; we cannot regard them as shear failure. Another representation of the data is the failure curve on the octahedral plane, also indicating the slight influence of the intermediate principal stress on the ultimate strength of sand stone.

Sepcimens were failed into a lot of thin slices with sound like an explosion in unconfined compression tests and di-axial compression tests. In tri-axial compression tests there occurred a few inclined failure surfaces to the major principal stress plane. We distinguish between cleavage failure and shear failure by the difference of cristal plane on which failure has occurred and the appearance of the collapsed plane. Thus we conclude that shear failure is predominant in the triaxial compression tests of which confined stresses exceed 20~40% of σ_c of the rock material and that the ultimate strength can be represented by the extended Mohr-Coulomb's crtierion. In the other cases the cleavage failures occur for which the above criterion cannot be applied. This conclusion has been confirmed by the photographic observation of failure planes using a cubic microscope.

Fundamental Studies on Settlements of Large Diameter Steel Pipe Piles

By Hisao GOTO and Tadashi KATSUMI

Transactions of the Japan Society of Civil Engineers,
No. 138, Feb., 1967, pp. 1–10 (in Japanese).

Abstract

This paper presents the results of some theoretical and experimental studies on the settlements of so-called large diameter steel pipe piles for both open and closed states of the lower pile tip. In the theoretical analysis, we assumed that the soil under the lower pile tip is semi-infinite elastic solid, and the skin-frictional stress has been assumed to be in elastic, elasto-plastic, and plastic zones. The model experiments have been worked out on two types of model piles in dry sand or sponge, one made of steel and the other made of metha-acrilic-acid, with various lengths and outer- and inner diameters. These models were tested for both open and closed states of the lower pile tip.

From the results of this study the following conclusions have been derived:

(1) We obtained the theoretical formula that gives the settlements and the load ratio producing equal settlements for both open and closed states of the lower pile tip.

(2) This load ratio decreases as diameter of pile increases, as thickness of pile decreases, as length of pile decreases, as elastic proportional coefficient of friction decreases, and as Young's modulus of soil increases.

(3) The results of model experiments and the result of practical field test support the appropriateness of the analysis using the above mentioned formula (1).

(4) Theoretically speaking, if the thickness of steel piles is greater than 20% of the diameter of the pile, the load ratio will be nearly equal to 1.0, otherwise it will decrease rapidly with decreasing thickness. From this result, we can state that it would be desirable from the view point of settlement to increase the thickness of piles over the length of about 1 or 2 m from the lower pile tip as well as to attach partitional plates to it.

Seismic Observations of Bridges and Ground in the Region of the Matsushiro Earthquakes

By Hisao GOTO, Kenzo TOKI, Yasuo YOKOYAMA, Hiroyuki KAMEDA, Takashi AKIYOSHI and Masahiro ISHIDA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 201-219 (in Japanese).

Abstract

In this paper the results of the spectral analysis of the Matsushiro earthquakes are presented and discussions are made from the viewpoint of earthquake engineering.

Since June 1966, observations of earthquake motions have been carried out at six stations in the region of the Matsushiro earthquakes. The seismic waves beneath the ground surface were observed at three stations by seismometers set in the bore holes. The response of bridges and embankments to earthquakes was observed at three bridge sites, and earthquake acceleration on the ground surface at two stations was recorded by strong motion accelerographs.

The Fourier spectra, the auto- and cross-correlation functions and the response spectra of the seismograms were computed, which gave some interesting information as to the variation of the earthquake ground motion along depth, dynamic coupling between the structure and the ground, and the filter effect of the structural system on the seismic motion.

The following conclusions have been derived.

(1) The intensity of earthquake ground motions in the deeper part of the surface soil layers is almost uniform along depth and is greatly amplified in the uppermost layers several meters thick.

(2) The ground close to the structural foundation moves in close relation to the structure, thus proving that the coupling between structure and ground plays an important role in the response of structures to earthquakes.

(3) The structural responses contain more periodic components than the record measured on the ground surface.

(4) As to the ground motions, it could not necessarily be said that periodic components will increase in the surface layers. It is sometimes the case that the periodic components predominant in the deeper part of the ground decay as they travel upward to give way to random components, and the periodic components become stronger again near the ground surface.

(5) The mean velocity of propagation of transverse waves in the ground computed from the cross-correlation functions of the earthquake motions recorded at different depths of the ground showed fairly good agreement with other data.

Seismic Observations in the Region of the Matsushiro Earthquakes

By Hisao GOTO, Kenzo TOKI, Yasuo YOKOYAMA, Hiroyuki KAMEDA, Takashi AKIYOSHI and Masahiro ISHIDA

Transactions of the Japan Society of Civil Engineers,
No. 145, Sept., 1967, pp. 1–11 (in Japanese).

Abstract

Presented are the results of observations of earthquake motions in ground and structures in the region of the Matsushiro earthquakes and of the analysis of the records obtained. The observation sites were selected at seven locations along the River Chikuma around Matsushiro Town. The measurement devices were arranged so as to record the information related to the variation of the characteristics of earthquake motion along depth of surface soil layers and relations between the ground motions and the structural responses in earthquakes and to supply earthquake acceleration records on the ground surface. The data observed were recorded on magnetic tapes, which were afterwards digitized and processed on a digital computer. Some of the conclusions derived from this investigation are as follows:

(1) The intensity of earthquake ground motions in the deeper part of the surface soil layers is almost uniform along depth, and is greatly amplified in the uppermost layers several meters thick. It would be of great interest to note this fact in treating the seismic forces acting on structures and their foundation constructions.

(2) The results of the analysis of wave forms with the aid of autocorrelation functions of the recorded data show that the structural responses contain more periodic components than the records measured on the ground surface, thus revealing the effect of the natural period of the structure not apparent in the raw records.

(3) The structural effects of the Matsushiro earthquakes were analyzed by the method of velocity response spectra which showed that the values of the velocity response spectrum S_V decrease for structures with large natural periods in the Matsushiro earthquakes in contrast with the general tendency that S_V takes on nearly constant values for different natural period of structures. This fact is consistent with the characteristics of earthquakes of medium magnitude observed near the epicenters. The acceleration response spectra showed that the earthquakes occurring in the Matsushiro area have the greatest effects upon structures with natural periods of 0.2~0.3 sec which would cause a maximum acceleration of 2~3 times the earthquake acceleration, while those upon the structures with a natural period greater than 1 sec is not great.

A Statistical Study of the Maximum Ground Motion in Strong Earthquakes

By Hisao GOTO and Hiroyuki KAMEDA

Memoirs of the Faculty of Engineering, Kyoto University,
Vol. 29, Part 4, Oct., 1967, pp. 389–419 (in English).

Abstract

From the randomness of the sequence of strong earthquakes and of the ground motion in earthquakes, it is considered essential to make a statistical evaluation of the intensity of the earthquake for which structures are to be designed. In this study, a statistical model of earthquakes was proposed that was consistent with the past records of occurrence of earthquakes and with strong motion accelerograms, on the basis of which methods were discussed to find the probability distribution of the maximum ground motin in a single earthquake and that for a certain future period. It is also of interest how to determine the intensity of earthquake motion in the response analysis in which the structure is subjected to an ensemble of random earthquakes. In this respect, the r. m. s. intensity of the earthquake ground motion was discussed.

The statistical model of the occurrence of strong earthquakes should be determined from the sufficient data of past earthquakes starting before modern science. In Japan, for example, a list of past destructive earthquakes is available for this purpose, which includes the earthquakes known from old documents to have occurred in the seventh century. However, one can readily understand that it is quite likely that many earthquakes which actually occurred in ancient times are missing in such a list. The statistical model of occurrence of earthquakes used in this study takes account of this possible time dependence of the record of past earthquakes.

The ground motion in earthquakes was treated as a continuous random process with normal distribution whose power spectrum has been determined from those for strong motion accelerograms. It has been found from comparison with the results of numerical simulation and with the theoretical upper and lower bounds that the Poisson process approximation is available with sufficient accuracy regarding the problem of the maximum value of the earthquake acceleration with such a power spectrum. The r. m. s. intensity of the ground acceleration corresponding to the intensity scale has been calculated.

With the aid of these statistical models of earthquakes, the probability distribution of the maximum earthquake ground motion in an arbitrary future period can be derived. From this probability distribution, the expected value of the maximum ground motion in a future period has been computed.

Foundations of Structures

By Hisao GOTO

JSSC, Society of Steel Construction of Japan, Vol. 3, No. 22, Oct., 1967,
pp. 19–28 (in Japanese)

Abstract

Civil engineering structures rest on their foundations with few exceptions, and they play a very important role in the aseismicity of structures. In this study discussions have been made on the analysis of vibration and earthquake response of structures and foundation constructions.

Since there are many unknown factors in the mechanism of interaction between the elemnts of the system composed of earthquakes, ground, foundation constructions and structures, only the linearly elastic vibration has been dealt with. The foundation constructions have been classified into direct foundation, pier foundation and pile foundation according to their mechanical characteristics. The direct foundation and pier foundation were treated as rigid masses supported by elastic ground, and the pile foundation was reduced to the spring system supporting the structure. These foundations were shown to be represented by the vibration models with two degrees of freedom accounting for translation and rotation. The theoretical analysis of these models was worked out and the practical method of numerical calculation has been shown.

The fundamental principle of the vibration and earthquake response of the structural foundation in the range of linear elasticity has been clarified by this study. However, further studies are indispensable in its application to aseismic design, since ground and the structural foundation exhibit complicated behaviour in earthquakes.

An Approach to Mechanisms of Groundwater Flow and Rainfall Loss

By Mutsumi KADOYA

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 3, Feb., 1967, pp. 11-21 (in English).

Abstract

A theoretical method for the estimation of the groundwater flow and rainfall loss, which means the difference between the rate or the total quantity of rainfall and its runoff component, in the area of a small mountain-stream is here described. As the first step of the study, the method is discussed in relation to the following assumptions on which it is based. 1) There is a simple relation between the infiltration capacity, f, and the soil-moisture ratio, w, in the surface layer of a drainage basin which is expressed as follows; $f=f_c+(f_u-f_c)\ (w-w_h)/(w_s-w_h)$ for $w_h \leq w \leq w_s$, where w_s means the saturated soil-moisture ratio, w_h the hygroscopic coefficient, and f_u and f_c mean the upper and lower limit of infiltration capacity respectively. 2) The above equation, derived for the infiltration capacity, can also be used for the recharge capacity, which is defined as the maximum recharge rate of groundwater and soil-moisture. 3) The recharge of groundwater occurs with the rate f_c only if the soil-moisture ratio in the surface layer equals or exeeds the maximum capillarywater capacity, w_c, 4) The discharge of groundwater flow is in proportion to the amount of water storage in the groundwater layer. 5) A simple relation exists between the evapotranspiration, E, and the soil-moisture ratio in the surface layer of the basin, w, as $E=E_p$ for $w \geq w_c$ and $E=E_p\ (w-w_h)/(w_c-w_h)$ for $w_c \geq w \geq w_h$, in which E_p means the potential evapotranspiration. 6) The depth of the imaginary surface layer related to the recharge capacity equals the actual depth related to evapotranspiration.

After the consideration of various elements, the theoretical equations for the recharge capacity, the increment of groundwater flow, and the recovery of recharge capacity are derived. By applying the method to the River Chama with a catchment area of 1.08 Km^2 at Kaikyo, in the northern part of Awaji Island, its usefulness has been made apparent.

Analysis of Groundwater Flow in Small Mountain-Streams (2nd report)

By Mutsumi KADOYA, Eiji TOYOKUNI and Toshio JYOTATSU

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 147-154 (in Japanese).

Abstract

The analysis of the groundwater flow of any stream channel system gives us a very useful and encouraging clue for solving the problem of water, and the problem of the loss capacity of rainfall defined as the difference between the rates of rainfall and of runoff as well.

This paper has proposed one method for conducting a consistent analysis of the groundwater flow and rainfall excess which contain the component of interflow, with a small mountain-stream as the object of study. This method is based on the concept of recharge capacity which is regarded as a part of infiltration capacity, and has dealt with a twofold analysis of groundwater flow and rainfall excess in relation to direct runoff by plotting a simple stream channel system on the supposition of the primary relationship between the moisture content of the soil, recharge capacity and evaporation. After some considerations, the theoretical equations have been derived for the recharge capacity, the increment of groundwater flow, and the recovery of recharge capacity.

The method proposed here has not often been put into practice regarding river data yet, but the case of the River Chama ($A=1.08\,Km^2$) located in the northern part of Awaji Island can be taken as an example to illustrate how the method has been applied. This area is an eroded region mainly composed of granite, its surface layer having a depth of 10~30 cm and being covered with copse. This region generally has an annual precipitation 1,100 mm and small ponds lie scattered in great number in the drainage basin.

As a result of applying this method, its usefulness has been made apparent. But the required computation is very laborious because the auto-recording data of rainfall are a prerequisite, which necessitates repeated trial calculations. So it is contemplated to find away of simplifying the process of calculation and also of making an analysis of some large scale stream channel hereafter.

Runoff Analysis in Paddy Field Basins

By Eiji TOYOKUNI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 155-167 (in Japanese).

Abstract

The method of runoff analysis in the drainage basin of a paddy field which may be extended with only a rectangular network system consisting of some lateral, branch and main drainage channels has been discussed in this paper. In such a system, the flow is apt to change from uniform flow to non-uniform flow with pondage action, and this tendency is rapidly accelerated when the discharge exceeds the capacity of the drainge channel.

First, by the physical considerations of each runoff characteristic of the flows related to lateral, branch and main drainage channel in the paddy field, a fundamental equation for flood routing in the system has been derived. It has been pointed out from the consideration that when the discharge exceeds the capacity of a drainage channel, the equation approaches the linear diffential equation, and the equation for the unit-graph is derived by using the technique of convolution in the Laplace transformation.

Next, on the basis of the above mentioned considerations, the limit of application of the unit-graph which has generally been adopted without recourse to theoretical reasoning in a paddy field basin, has been discussed.

The runoff patterns in the paddy field are classified into three types as follows: (1) non-linear system, where the greater part of the runoff process has the runoff characteristics of the non-linear, (2) linear system, where the greater part of the runoff process has the runoff characterics of the linear, (3) linear-nonlinear system, a mixed system having both linear and non-linear. It has been theoretically verified that the application of the unit-graph method is limited to the linear system out of all these systems. By applying the above theoretical results to the River Masuda with a drainage basin area of 3.97Km^2 at Masuda, in the northern part of Lake Biwa, the limit of application of the unit-graph has been made apparent.

In this basin, when the sum of effective rainfall exceeded about 30mm, the runoff pattern in the basin approached the linear system for whole duration of the flood, because the discharge capacity of the channel network is extremly small and the storage in the paddy field and channel system increases rapidly with rainfall.

A Theoretical Study on the Two-dimensional Flow of Unconfined Ground Water

By Gyozo OHASHI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 169–181 (in Japanese).

Abstract

A two-dimensional approach to unconfined groundwater flow from the mountain area or the river to the drainage channels in the alluvial fan is discussed in this study. The two-dimensional situation for the flow is based on the assumption that the basin may be divided into several basins of rectangular shape, each bounded by a drainage channel on two parallel sides, and that the ratio of both length and width to depth from a free surface to a sloping impervious base is so large that the vertical changes of the hydraulic characteristics of the seepage flow are negligible.

The fundamental equation has been developed for the unsteady flow, and some of the hydraulic significances of the parameters included in this equation have been discussed.

For the purpose of clarifying the fundamental characteristics of the flow, a solution of the steady flow equation is first obtained by the technique of the numerical calculations, and the effects of seepage flow into a ditch are especially examined.

Secondly, to obtain the analytical solution the steady flow equation, the following technique has been discussed by referring to the characterics of the flow obtained with the above mentioned numerical calculations as follows: the seepage flow in the rectangular region may be divided into both longitudinal and lateral flows which mean the parallel and orthogonal flows to the drainage channel respectively, and both flows can be related to the recharge elements, which are defined as the difference between inflow and outflow through the section in unity width at any point in the longitudinal flow.

Finally, the results obtained by this analytical method have been tested against the numerical results.

A Stochastic Consideration of the Variation of Hydrological Quantities

By Mutsumi KADOYA

Proceedings, International Hydrology Symposium, Fort Collins, Colorado, U. S. A., Vol. 1, Sept., 1967, (in English).

Abstract

It is a serious problem for hydraulic planning whether or not in the sequence of hydrological quantities cyclic or periodic variations exist. In this paper, first, the general character of the long-term variations in the sequences of annual sum and annual maximum of daily precipitation and of river runoff in Japan have been examined using the technique of over-lapping moving average ; and it has been discussed that the secular variations of the hydrological quantities having the characteristics of short duration, such as the annual maximum daily precipitation, seem to be more random than those having the average characteristics of long duration, such as the annual sum of precipitation.

Next, the possibility or the limit of stochastic prediction for the sequential variations of hydrological quantities by the technique of time series analysis has been considered. As a result, it can hardly be concluded that the long-term hydraulic project can draw much advantage from the way in which the stochastic prediction is ordinarily made. Hence, it has been discussed that since the possibility of the prediction is governed mainly by the power of the singular variations in the sequence, the simulation technique should be adopted in order to involve the character of secular variations of hydrological quantities in hydraulic planning.

The following methodologies in this connection have been proposed: As to the long-term variation, even when a definite trend immediately corresponding to the increase and decrease of sunspots is revealed by available data, the very evidence from a single case of only one cycle would not be sufficient to prove the existence of such a trend. Consequently it is suggested that under such circumstances it would be safe to make it a singular process with the same period as its trend. As to such cyclic variations that are revealed to the degree of N / 2-N / 5 in the sequences, first the correlogram is to be obtained in regard to the particular cycle extracted by means of an adequate moving average, and then the model of an anto-regressive process of the 2nd order is to be plotted using such coefficients of correlation read at about quarter intervals of this period. As to the short-term variations, the model of an auto-regressive process of the 2nd or higher order is to be adopted in the same manner.

On the Flood Flows Expected in the River Hime

By Nobutada TAKASE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 33-39 (in Japanese).

Abstract

The river Hime flows north into the sea of Japan, rising in Nagano prefecture. It is one of the most ruined torrential rivers in Japan. The basin area and length of the river channel are 722 km^2 and 60 km, respectively. People said that there was a great flood in 1912, but no data on the flood was recorded. Hydrological data were not collected before 1954, so only a little recent data is available to analyze the expected flood of the river.

In Japan, the run-off phenomena for river basins with much available hydrogical data have been researched from many points of view in order to contribute to the rationalization of river planning, but the run-off analysis for river basins with only a little available hydrological data was so difficult that satisfactory results have not been obtained so far, thereupon the author analyzed the expected flood in the river Hime with only a little available data, utilizing the results of recent hydrological researches.

In this paper, first the annual maximum two days amount rainfall in the basin was estimated. The results were consided with the aid of the time series theory, and the probabilities of rainfall were calculated. Secondly, the author made a few remarks with regard to the process of the analysis, and calculated the expected flood hydrographs by transforming the rainfall into the discharges with the run-off function. Moreover, as no data was recorded in the river Nechi, the tributary of the Hime, the hydrographs were estimated with the aid of the synthetic unit hydrograph based on Dr. Tojiro ISHIHARA's method applicable to rivers in Japan.

By using these results, the author briefly considered a method of calculation of the expected flood in a river having only a little hydrological data, for example the river Hime. It contributes to the determination of the high-water discharge which is the most important factor in rational river planning.

Some Observations on the Sediment Yield and Transport in a Mountain Watershed

By Katsumasa YANO, Yoshito TSUCHIYA and Takenobu OKUMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 81–96 (in Japanese).

Abstract

Since 1965, the authors have been carrying on some observations on the sediment yield and transport in a mountain watershed, called the Hiru-dani Experimental Watershed.

The watershed is a tributary of the River Jintsu and is located in the southern part of the Japan Alps in Gifu prefecture, at 1,200m to 2,000m above sea level. The longitudinal profiles of streams are inclined from 1/5 in the lower part, to over 1/3 in the upper part. The geology of the watershed is paleozoic, mainly schalstein and quartz-porphyry in part, and although some scars appear on the valley head and around the terrace, sediment yield is not so severe as the surrounding watershed.

Variations in concentration of sediment during flood—Generally, the peak of concentration occurs nearly together with the peak of discharge, in which case sediment yield is not so severe, but as the basin area is narrow, about 0.85 km^2, we cannot debate about the time lag between these two peaks until more detailed data has been gathered. Nor can we explain a definite relationship between the maximum of concentration and the peak discharge, as they differ according to circumstances, where and how many erodible deposits exists in the basin, when cones of debris fall down, how long flood or precipitation lasts or how intensely it rains.

Deposition upstream of the check dam—Deposits upstream of the check dam at the basin mouth are surveyed after each flood. As no striking landslide ocurred in 1966, it is considered that the sediment mostly depends on surface erosion. Therefore, referring to cumulative precipitation, a remarkable relation to rainfall over 5 mm per 30 minutes in intensity is discoverable. And the delta in river bed upstream of the check dam advanced quite similarly to the results of laboratory work on the mechanism of deposition of bed load.

Variations in conductivity and water temperature—Besides the measuring of sediment concentration, variation in conductivity and water temperature are measured at the same time. Although, as results indicate a converse correlation between conductivity and water discharge, water temperature positive, it cannot be clarified whether these facts relate directly to sediment yielding or only to flooding itself.

Experiments on the Mechanism of Movement of a Spherical Sand Particle on a Granular Bed in Turbulent Streams

By Yoshito TSUCHIYA and Minoru SUMINO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 97-107 (in Japanese).

Abstract

It is one of the most important problems in sediment hydraulics to establish the mechanics of movement of a sand particle in a turbulent stream. Some experiments on the motion of a spherical sand particle and the force acting on it were carried out with a storoboscope to clarify hydrodynamic behaviour. It was concluded from the results of the expriment that there are two types of motion of a particle ; rolling or sliding and saltation, and the uplift force acting on a particle may be not so great as Yalin and Kishi used in their computation of saltation. It was also clear from the experiment that both the mean rollig distance of a particle and the standard deviation of the distribution decrease with the square of the shear velocity. With regard to the theoretical considerations of the rolling motion, an equation of motion for rolling of a particle is established by using the quadratic resistance law of drag and the friction law in uniform friction fields. It was verified from the comparison between the theoretical relationship and the experimental results of mean rolling velocity of a sand particle that the theoretical curves using a suitable value of friction coefficient are in good agreement with the experimental values.

With regard to the characteristics of saltation of a particle, changes of saltation height and distance of a particle are clarified and it was especially found that both the saltation height and distance increase with the square of shear velocty or representative velocity in a saltation layer, as verified already in the mechanics of sand transport in the air.

Friction Factor and Velocity Distribution in the Turbulent Region for Bingham Plastic Fluid

By Atsuyuki DAIDO and Sigeyuki KUSAKABE

Proceedings of the Fifteenth Japan National Congress for Applied Mechanics, 1965, 1967, pp. 192–196 (in English).

Abstract

There are two types of non-Newtonian fluids useful to an engineer; the first is power law fluid and the second Bingham plastic fluid. Recent researches on the friction factor and velocity distribution in the turbulent region of non-Newtonian fluid were treated mainly as power law fluid. But, the most interesting non-Newtonian fluid in the civil engineering field is Bingham plastic fluid. For Bingham plastic fluid, however, it seems that suitable considerations have not been proposed yet, except those on the friction factor in smooth pipes.

In this paper, the friction factor for Bingham flows in smooth and rough pipes and the velocity distribution in the turbulent region for Bingham plastic fluids are considered by experiment and theory.

Experimental studies on the friction factor in the turbulent region for Bingham fluid flowing through smooth and rough pipes are described. The relation between the friction factor and the modified Reynolds number is expressed by the logarithmic law similar to that for Newtonian fluid. Then the velocity distribution and the friction factor in the Bingham flow were theoretically derived on the assumption that the mixing length theory can be applied to obtain the Reynolds stress in Bingham plastic fluid.

It is concluded that the constants in the velocity distribution and the mean velocity formula, and the thickness of sub-layer can be expressed as functions of τ_Y/τ_0 respectively, in which τ_Y is the yield stress and τ_0 the boundary shear stress, because the coefficient in the relation of friction factor derived by the theory is constant within the experimental accuracy.

Measurement of velocity distribution was carried out using a vinyl pipe 4.09 cm in diameter. Two velocity distributions which have values nearly equal to τ_Y/τ_0 but different in the modified Reynolds number can be plotted on one curve.

The values of κ estimated from the gradient of the curve for velocity distribution showed that the above consideration is valid in the region where $\tau_Y/\tau_0<0.15$.

Air Pollution and Local Climates of Kyoto, Osaka and Kobe

By Chōtaro NAKAJIMA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 1-9 (in Japanese).

Abstract

The eastern part of the Seto Inland Sea and the central part of the Kinki district have an inland-type climate. In the winter season a cold air lake with stable and calm air favourable for the high concentration of air pollution is often formed in these areas, especially when the weak trough between two anticyclones is located over these areas or after an anticyclone has gone over them. The temperature of the sea surface in the Seto Inland Sea is 5°~10° C lower than that near the Pacific coast of the Kinki district in the winter season. A remarkable discontinuity of the temperature is seen near the souhtern end of Osaka Bay.

Kyoto, Osaka and Kobe are located in the central part of the Kinki district. The vertical inversion of temperature near the surface occurs most frequently in the Kyoto basin, but not frequently at Kobe which is located along the coast of Osaka Bay at the foot of the mountains. At Kobe, the wind direction and speed are most important factors for air pollution. Sources of air pollution are most plentiful in the City of Osaka, so a high concentration of air pollution frequently occurs in this city. However, after the monsoon has begun to weaken, the surface wind first weakens in the Kyoto basin. In such a case the concentration of air pollution in Kyoto is higher than that in Osaka. The intensity of the inversion of the temperature in Kyoto is well represented by the difference between the minimum temperatures on Mt. Hiei (848.3 m) and in the Kyoto basin. When the value of the difference is lower than about 2°C, a high concentration of air pollution is observed in Kyoto. This fact is statistically illustrated. This relation may be useful for the forecasting of air pollution in Kyoto.

On the Rainfall over the Southern Kinki District

By Yukio Gocho

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 11–18, (in Japanese).

Abstract

In order to know precisely the relation between the state of the upper air and rainfall, the relations of static stability and the south-wind component of the mean wind in the lower troposphere to 24-hour precipitations (since 09h JST) over the rainy southern Kinki district in the warm season for two years are investigated. Our objective region is the area within about 100 kilometers of Shionomisaki located at the southern end of the Kinki district and about 7,500 square kilometers wide. As 24-hour precipitations we take (a) precipitation at Shionomisaki where upper air observations are carried out, (b) maximum precipitation in the objetive region in which there are 42 stations for rainfall observation, and (c) mean precipitation in the same region calculated by the Thiessen method. The stability index proposed by Showalter is adopted as static stability. We use here the south-wind component of the mean wind in the layer of 0.5~5.0 kilometers level for the horizontal water vapour flux, because a considerably high correlation between them is indicated.

Examining the relations between the above-mentioned 24-hour precipitaions and the minimum stability in the three observations at 09,21 h on the same day and 09 h on the next day, it is found that in heavy rainfalls the stability indices are almost within the range $1°\sim -2°C$ for any kind of precipitation. It seems that the lower troposphere is nearly saturated and the lapse rate is moist adiabatic in heavy rainfalls. The relations between the 24-hour precipitations and the maximum south-wind component of the mean wind in the five observations at 09,15,21h on the same day and 03,09h on the next day are as follows: precipitation at Shionomisaki is not always heavy for the large south-wind component, the maximum precipitation in the objective region tends to increase according to the south-wind component, and the mean precipitation in the region has the same tendency but is more noticeable. When the mean precipitation is 50 millimeters or more, the south-wind component of more than 10 m/sec is always observed. It is suggested that the strong south-wind component of the wind in the lower troposphere is necessary for considerably large scale heavy rainfall.

Basic Study on Salt Damage (I)
Production of Sea-Salt Particles and a Model of their Transport Inland

By Yoshiaki TOBA and Masaaki TANAKA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 331–342 (in Japanese).

Abstract

Salt damage is caused by sea-salt particles, which are supplied from the sea surface to the atmosphere, and transported by advection and turbulent diffusion to the land. In this report, basic problems concerning the production, transport and distribution of the sea-salt particles are summarized and discussed, from the view point of salt damage.

The predominant mechanism of the supply of sea-salt particles to the air is the bursting of air bubbles, which are entrained in wind waves. When wind speed becomes stronger than several meters per sec, troughs of small wavelets, which are superimposed upon gravity waves, point downward, and air bubbles are entrained into wind waves at the troughs of the wavelets. When the bubbles burst at the sea surface, three classes of sea water droplets are produced. The largest drops, jet drops, have diamers of 10 to 15 % of that of the mother bubbles. The droplets from bubble film have dry masses of 10^{-10} to 10^{-12} gm. The third class is of much finer droplets. The sea-salt particles responsible for the salt damage are from the first two classes: giant sea-salt particles.

An estimate of the number concentration, salt-mass concentration, and production rate of various dry-mass classes of the giant sea-salt particles at the sea surface and at the coast, are presented as a function of wind force and relative humidity.

A model of the transport of the sea-salt particles from the sea surface to the inland is presented as a solution of the diffusion equation. The particles have a vertical distribution expressed by an exponential form over the ocean. But when the vertical distribution is carried over the land, the concentration near the ground decreases rapidly due to capture of the particles by ground obstacles and by sedimentation. The distribution over land is formulated by using dimensionless variables representing altitude, distance inland, number concentration, and impaction-sedimentation ratio. This ratio plays an essential role in determining the main feature of the distribution of the particles over land, and hence it has great significance in the problem of salt damage. A preliminary estimate of the ratio gives a value of the order of 10 to 100.

On the Hydraulic Model Experiment on the Diffusion Due to the Tidal Current

By Haruo HIGUCHI and Takashige SUGIMOTO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 343-363 (in Japanese).

Abstract

The diffusion phenomena due to the tidal currents in a broad shallow estuary are here studied in a hydraulic model experiment, for which the Omuta area in Ariake Bay, Kyushu, is used as the prototype. Only the tidal currents are taken into account; other factors, such as the ocean current, density stratification, wind, and waves, which may influence the diffusion in the estuary, are not considered.

A 20 by 25 meter model of the northern half of Ariake Bay, with horizontal and vertical scales of 1/2000 and 1/200 respectively, was constructed. A semi-diurnal tide was generated by an automatically controlled pneumatic tide generator. The water level at 5 stations, the curent ellipses at 4 stations and the flow pattern were measured and compared with those in the prototype. The diffusion from instantaneous point sources and a continuous point source was investigated by photographic method and dye concentration analysis.

Experiments have shown that the tide and the tidal current are accurately reproduced in the model. The diffusion coefficient evaluated through the mixing of the water discharged from the River Chikugo with the sea water in the area is almost the same as in the prototype. The diffusion coefficients evaluated through the rate of increase of the dye patch from instantaneous point sources are about 1/3 of those in the prototype. This may be due to the difference between the flow in the prototype, and that in the model the former belonging to the perfect turbulent regime and the latter to the transient regime. The diffusion coefficient in the model at a future stage, in which two areas of reclaimed land are presented, becomes a little larger than those at the present stage. The diffusion from a continuous point source at the mouth of the River Omuta is also investigated, and the process of accumulation of the dye is observed.

This paper is the final report for the hydraulic model experiment on the diffusion in the Omuta area. An interim report was published with the title "Hydraulic Model Experiment on the Diffusion Due to Tidal Current" in the proceedings of the 13th Conference on Coastal Engineering in Japan held in December, 1966.

On Tidal Currents off Eastern Harima Coast (II)

By Haruo HIGUCHI and Shigehisa NAKAMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 365-373 (in Japanese).

Abstract

A series of observations of tidal currents has been carried out continuously near the Eastern Harima Coast.

From the result of tidal observation for about five hours by use of a propeller type current meter, it was found that there are, in addition to the tidal currents, various currents with periods ranging from 2 sec to 48 min. These were found by harmonic analysis of the automatic records of tidal currents obtained from the current meters. From the results of these analysis, it was found that short period components of current might be induced when the tidal currents reverses, and develop only for about one hour after the tide turns. After that, these components decay away.

Besides the above short ranged observation of tidal currents, an analysis of tidal currents for about a fortnight was carried out. Tidal constituents and seiche are also studied by refering to the results of the observations carried out by the Kinki Regional Construction Bureau, Ministry of Construction. From the harmonic analysis of tidal observation which were carried out by a FACOM 331 Electronic Computor, it became clear that the non-linear effect of tidal currents is important and the component of seiche in the Harima Nada is about one tenth of the observed current velocity. Mixed (or hybrid tidal ellipses were also reduced for 12 days from 1 Oct., 1965. Apparent amplitude is at a minimum two days after the first quarter and a maximum about two days after the full moon. The minimum amplitude is 1 m/sec and the maximum is about 2.5 m/sec. Harmonic components other than the first and second components (mainly the diurnal and semidiurnal constituents) suggest the influence of non-linear factors, such as topographical and inertial ones, exert.

Hydraulic Model Experiment on the Diffusion Due to the Tidal Current

By Haruo HIGUCHI

Proceedings of the 12th Congress of the International Association for Hydraulic Research, Sept., 1967 (in English).

Abstract

The diffusion phenomena due to the tidal currents in a broad shallow estuary are here studied in a hydraulic model experiment, for which the Omuta area in Ariake Bay, Kyushu, is used as the prototype. Only the tidal currents are taken into account; other factors, such as the ocean current, density stratification, wind, and waves, which may influence the diffusion in the estuary, are not considered.

A 20 by 25 meter model of the northern half of Ariake Bay, with horizontal and vertical scales of 1/2000 and 1/200 respectively, was constructed. A semi-diurnal tide was generated by an automatically controlled pneumatic tide generator. The water level at 5 stations, the current ellipses at 4 stations and the flow pattern were measured and compared with those in the prototype. The diffusion from instantaneous point sources and a continuous point source was investigated by photographic method and dye concentration analysis.

Experiments have shown that the tide and the tidal current are accurately reproduced in the model. The diffusion coefficient evaluated through the mixing of the water discharged from the River Chikugo with the sea water in the area is almost the same as in the prototype. The diffusion coefficients evaluated through the rate of increase of the dye patch from instantaneous point sources are about 1/3 of those in the prototype. This may be due to the difference between the flow in the prototype, and that in the model the former belonging to the perfect turbulent regime and the latter to the transient regime.

This is translated into English from the paper of the same title published in the Proceedings of the 13 th Conference on Coastal Engineering in Japan held in December, 1966.

Potential Gradient and Radar Echo from an Isolated Thunderstorm

By Toshio OGAWA and Yukio GOCHO

Special Contributions, Geophysical Institute, Kyoto University,
No. 7, Dec., 1967, pp. 57-60 (in English).

Abstract

During the passage of a thundercloud near an observation site W type variation is most frequently observed on the recording of the potential gradient. This fact leads to a generally recognized electric charge distribution in a thundercloud of positive polarity with a small pocket of positive charge in the lower center of the main negative charge. Kuettner (1950) imagined from his measurement at the Zugspitze that the lower positive charge is generated in a strong downdraught which is in the center of electrical activity. The charge generates at the temperature level of $-8°C \sim 0°C$, where graupel is growing. On the other hand Wichmann (1952) has suggested that the pocked charge is produced at the temperature level of 0°C or higher, so that liquid water plays a role in the charge production.

In the summer season of 1965, simultaneous observations were made of the surface potential gradients and the radar echoes from a thundercloud by using an 8.6 millimeter wave radar (REI : Range elevation indicator) in Kyoto city. During 12h — 13h JST on August 24, the electrical disturbance of an isolated thundercloud was observed and the radar echoes were also almost fully observed in the period from 12h 30m — 12h 59m. Until the potential gradient recovered finally to the normal positive value since 12 h 30 m, there seemed to be two positive-ward excursions of the gradient in the middle of the electrical disturbance. These excursions were almost exactly associated with the sudden rising of the radar echo tops. Especially in the last case it was very remarkable with the positive maximum potential gradient value, and the echo top rose to the highest level and remained there for about ten minutes or more. It is suggested from these observed facts that the lower positive pocket charge in a thundercloud is produced in a strong updraught during the growth of a cloud tower.

Simple Technique for the Measurement of Giant Sea-Salt Particles by Use of a Hand-Operated Impactor and a Chloride Reagent Film

By Yoshiaki TOBA and Masaaki TANAKA

Special Contributions, Geophysical Institute, Kyoto University,
No. 7, Dec. 1967, pp. 111-118 (in English).

Abstract

The design and the use of a hand-operated jet impactor are described, by which giant sea-salt particles in six different volumes of air may be sampled on a chloride reagent gelatin film of 1 cm^2. Some practical notes on the preparation, calibration and reading out the reagent film, which is used with the impactor to determine dry masses of the giant sea-salt particles, are also presented.

An air jet is formed at the air intake, which is an orifice of 1 mm in diameter, with a 100-cc hypodermic syringe, and giant particles impact on a circular area on the reagent film. By rotating a film-mounted stage with a handle, six different volumes of air, for example, from 0.25 l to 8 l, may be sampled successively. Needle marks are made on the film alternately with the sampling, for the identification of the areas of halos in a microscope examination.

Sea-salt particles larger than 1 μ in diameter are considered to be collected with 100% collection efficiency by the impactor, when the syringe is drawn at a speed of 3 sec per 100 cc or faster, corresponding to a jet speed larger than 40 m per sec.

Concerning the determination of absolute number concentration, a possibility that particles once collected on the sampling surface be again blown off by the air jet, is noted and discussed, and a retention factor is estimated from some experimental data. Also, the effect of the overlapping of the reaction halos is studied.

The use of the chloride reagent film is a slight modification of Farlow's method. Fuji Gravure Film Normal is used to prepare the reagent film, which contains reddish brown sediment of silver dichromate in the transparent gelatin layer. The relation between the dry masses of sea-salt particles m in 10^{-12}gm unit, and the diameter of the halos D in μ, is determined by an aid of isopiestic method. The calibrated relation between them is

$$\log m = 2 \log D - 0.714.$$

By use of the reagent film, the dry masses of sea-salt particles larger than 10^{-11}gm are safely measured. The reading of the halos for various dry-mass classes is easily performed by use of a specially designed transparent scale.

Vane-Triaxial Tests on Anisotropically Consolidated Samples

By Toru SHIBATA

Internal Report of Norwegian Geotechnical Institute, F. 257-5,
Oct., 1967, pp. 1-28 (in English).

Abstract

This paper, which was prepared during the writer's tenure as a Post-Doctoral Fellow at the Norwegian Geotechnical Institute, presents the results of investigations of the following two topics: (1) the effective normal stress on the failure surfaces at the stage of maximum shear resistance in the vane test and (2) the effect of anisotropic consolidation stress on the shear strength measured in the vane test.

The tentative conclusions reached are listed below: (1) The results of the consolidated-vane test on Manglerud clay, in which the sample consolidation was allowed after vane penetration, have shown that a substantial increase in shear strength occurs. The comparison of such an increased strength with the results of constant-volume direct shear test indicated that the effective normal stress on the failure surface at failure in the vane test, σ_N', can possibly be greater than the initial consolidation stress. (2) In the case of Kaolin clay, the comparison of the isotropically consolidated vane and constant-volume direct-shear test indicated that the degree to which σ_N' changed during the vane test, σ_N'/σ_c', is $0.9-1.1$ at τ_{max} conditions. Although it has not been confirmd, the cause is believed to be a rapid dissipation of excess pore pressures induced along the failure surface. (3) The maximum shear stress developed on the horizontal failure surface of the vane, τ_H, is essentially independent of the horizontal consolidation stress, σ_{3c}, but primarily dependent on the vertical consolidation stress, σ_{1c}. On the other hand, the maximum shear stress developed on the vertical failure surface of the vane, τ_v, is dependent on both of these σ_{1c} and σ_{3c}. In the case of Manglerud clay, τ_v was however independent of σ_{1c} but primarily dependent on σ_{3c}, and this can possibly be explained by a loss of cohesion component at τ_{max} condition. (4) If the above statements were true it would mean that the $c/p-$ ratio measured in the vane test on normally-consolidated clay (with the exception of pure cohesive soil) would be decreased for decreasing value of $K = \sigma_{3c}/\sigma_{1c}$ and that the c/p-ratio corresponding to $K = K_0$ condition (where K_0 is the coefficient of earth pressure at rest) would be much smaller than that corresponding to $K = 1.0$.

Varied Flow in an Open Channel with Bottom Diversion Racks

By Hiroji NAKAGAWA and Tadashi UTAMI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10B, March, 1967, pp. 183–198 (in Japanese).

Abstract

It is often necessary for the design of a stream channel to develop a general method for analysing open channel flow with varying discharge, together with the practical aspects of design. The flow on bottom diversion racks may sometimes be treated as the gradually varied flow, while the local phenomena around the racks must be analysed as rapidly varied flow.

In this paper, research is first done on the coefficients of outflow discharge by experiments to show that they are given as a function of initial Froude number, and the applicability of gradually varied flow theory to analysis of the water surface profile is discussed. Next, the transition profiles of water surface on the racks are examined on the basis of the fundamental equation including the terms of vertical componts of velocity.

As to analysis of the rapidly varied flow, the subcritical transitional flow with locally large outflow is investigted. Velocity, pressure distributions and coefficients of outflow discharge are obtained theoretically by assuming the flow pattern model where the centrifugal components of velocity vector are uniformly distributed on the concentric circle and components parallel to bottom are uniform throughout the range. According to these results, the relative depth of flow and energy loss are obtained as the function of the initial Froude number. Comparison of these results with experimental values verifies the method of analysis. Finally, the method of flow visualization is suggested to analyse the local phenomena.

On Currents with Storm Surges near River Mouths

By Shigehisa NAKAMURA

Journal of the Oceanographical Society of Japan, Vol. 23, No. 4,
August, 1967, pp. 175–181 (in Japanese).

Abstract

There exist scarcely any reliable records of storm surges even near coasts and river mouths. In this study, currents with storm surges near river mouths are studied experimentally by use of a hydraulic model of the rivers and canals in Osaka City. This model has proved capable of reproducing water level changes caused by past representative storm surges. There is a plan to construct gates in the rivers in Osaka City to prevent innundation by future storm surges ; currents have been studied under two conditions : (1) before construction of the gates and (2) after construction of the gates.

In the model experiment, paths of floats were observed by photographic tracking with exposures every 10 or 15 seconds for 5 different design storm surges with the peak O.P.+5.4m. Path length of the floats and their residue were considered in relation to time duration of the storm surge in the model experiment; no regularity was found, presumably because the rivers and canals were not uniform in their width and their water depths. Interaction between the rivers and canals is indicated.

The currents were deduced from the derivative of the path length of the floats. It was fouud that maximum current velocity on the paths has a relation to the time duration of the storm surge. This is expressed experimentally as $u_{smax} = a \cdot T^{-3/4}$ for the neighbourhood of the river mouths in the model, although theoretical consideration suggests that $u_{smax.}$ is inversely proportional to the time duration of the storm surges T.

Experimental Investigation of the Behavior of Frames with and without Bracing under Horizontal Loading

By Minoru WAKABAYASHI and Bunzo TSUJI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 2, Jan., 1967, pp. 81–94 (in English).

Abstract

For the aseismic design of the structures, the restoring force characteristics under horizontal loading should first be clarified. The load-displacement curve of steel structures is generally of a softening type: the structures, some members of which sustain a large compressive force, show a different type of load-displacement curve. In this report the behavior of the frames with and without bracings under monotonous and repeated horizontal loading is examined experimentally. Tests are made for single bay one and two-storied rectangular frames with and without bracings. The adopted bracings are single, K-truss type and cross-diagonal bracings. The specimens are made of members with mild steel wide-flange sections. In order to prevent lateral buckling, two dentical frames are welded together at several points. Horizontal load is applied statically at the top of the columns, until local failure or large out of plane deformation takes place. Repeated loads are applied statically by increasing the deflection amplitude at each half loading cycle.

The load-displacement curve of the frames without bracing shows a softening type, and under repeated loadings spindle-shaped ones. The frames with bracings show unstable equilibrium at the instant of buckling of the compression bracing, and the load increases slightly with an increase of the displacement or keeps nearly the constant value. Under repeated loadings, the load-displacement curves show similar characteristics to the monotonous ones in the small deflection range. With the increase of deflection the unstable phenomenon disappears, and the curves show a spindle shape. The slope of the curves in the process of unloading gradually deteriorates as the deflection amplitude increases. Local buckling of the member occurs at the smaller displacement when the axial compressive force is large. Under repeated loadings, local buckling occurs at 10-20% smaller displacement than that under monotonous ones. In the case of the frames without bracings the equivalent viscous damping coefficient ratio which indicates the capacity of the energy absorption due to the plastic work becomes larger with the increase of the displacement amplitude. The frames with bracings show a large value in the ratio at small deflections, and as the deflection increases the ratio increases slightly or remains constant.

Large Plastic Deformation of a Structure due to Impact ···An Experimental Study on a Portal Frame Subjected to Impulsive Loading, Report No. 1···

By Minoru WAKABAYASHI, Taijiro NONAKA and Koichi MINAMI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 391-406 (in Japanese).

Abstract

When a structure is loaded with a load greater than its static collapse load, no equilibrium of stress state can exist. Under these circumstances, an accelerated motion starts. The structure will undergo a large deformation and may rupture or otherwise become unserviceable if such motion continues for any appreciable time. However, if the time of load application is short enough, the inertial resistance of the structure may be sufficient to prevent excessive deformation. The purpose of a dynamic plastic analysis is to estimate the permanent deformation of a structure under these circumstances.

Numerous experimental investigations have been made to determine the permanent deformation of beams due to dynamic loading. Most of them measure the total impulse or impact velocity, disregarding the acceleration time or load time relationship. However, in the case of rigid-perfectly-plastic beams or framed structures subjected to impact forces which are of the same order of magnitude as the static collapse load, the measurement of the load magnitude or the load duration time is important as well as the total impulse. We attempted to measure the impact forces by a piezo-electrical method here.

A preliminary test was performed for the study of large permanent deformation of columns in a portal frame, a horizontal impact load being applied at the top of the frame model. The column specimens were made of mild steel or aluminum alloy plates. The column height was approximately 10cm. The beam was made of a metal block to be rigid as compared with the columns, and was repeatedly used. The impact load was applied by detonating an electric blasting cap or by means of a ballistic pendulum. In the latter case, Barium Titanate was attached to the center of the beam cross section to record the voltage-time relation during the impact loading; the load was calculated from the voltage on the basis of a linear relation between them. In the former case of a blasting cap, the measurement of load-time relation was not attempted. The applied impulse was calculated from the swings of a bifilar pendulum. The permanent deformation of the column specimens was measured by a dial gauge after testing.

The theoretical analysis follows the principle introduced in an earlier paper, and a general consensus is seen with the experimental results.

An Experimental Study of the Restoring-Force Characteristics of Tall Frames

By Minoru WAKABAYASHI and Shosuke MORINO

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 407–416 (in Japanese).

Abstract

For the dynamic analysis of frames under horizontal varying forces, such as wind or earthquake disturbances, the relation between the horizontal forces and the displacements is of primary importance. The restoring-force are decreased with vertical loads, which may make the restoring-force characteristics unstable, especially in the lower parts of tall frames. In order to investigate the effects of the vertical loads on the restoring-force characteristics of frames under horizontal loads, 12 model tests are carried out. The models are cut out by machines from mild steel plates of 60mm thickness. Plane single-bay three-storied frame models are tested. The ratio of the section modulus of the column to that of the beam is taken as 0.5 or 2.0. Each frame member is 150mm long. The constant vertical loads of 0, 20 and 40% of yield loads of columns are applied to the top of the frames, and the horizontal load is applied to the beam of the top storey. The relations between horizontal load and horizontal displacement are measured. The curves obtained by this experiment are compared with the slope-deflection theory with consideration of the axial forces of columns, in which it is assumed that 1) both the stress-strain relation of the material and the bending moment-curvature relation of members are perfectly elasto-plastic, 2) the changes in the axial forces of the columns caused by the shearing forces of beams are neglected. The following results are obtained: 1) the slope-deflection theory agrees with the test results in the elastic range; in the elastic but partly plastic range it gives larger values; in the process of collapse it predicts too a most unfavorable a situation, 2) a large vertical load induces in a frame an unstable state before a sufficient number of plastic hinges have been formed, corresponding to plastic collapse, 3) the decrease of the horizontal load after the bearing capacity is reached becmes more rapid when the vertical loads become larger, 4) the horizontal displacement which corresponds to the maximum force decreases when the vertical loads become larger, but increases as the section modulus of beams increases, 5) the horizontal bearing capacity decreases when the vertical load is increased and it can be approximately estimated, on the safe side, by a Rankine type equation which linearly relates the maximum horizontal force and the vertical load.

An Experimental Study of the Elastic-Plastic Stability of Steel Frames with Wide-Flange Sections under Vertical and Horizontal Loading (Part 2)

By Minoru WAKABAYASHI, Taijiro NONAKA and Chiaki MATSUI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 417-430 (in Japanese).

Abstract

An experimental study is made of the effects of vertical loads on the restoring force characteristics of single-bay, two-story, end-fixed frames with mild steel wide-flange sections under horizontal loading. Test specimens are rigid frames of continuous welded construction and composed of two similarly made plane frames, both being connected to each other with wide-flange sections at the joints and at the centers of the beams and columns to prevent lateral buckling of the frame. Four specimens are tested. All columns of specimens have an H-100mm×100mm section and beams H-100×100 or H-100×50. The beam length and column height are equal and they are both 100cm. The ratio of the column height to the in-plane radius of gyration is about 24 which is chosen as the representative proportion of a typical frame commonly used in Japan. The moment of inertia of the beam is either equal to or 0.43 times that of the columns. The test specimen is fixed on an L-shape supporting frame at the foot of the lower columns with high-tension bolts. The supporting frame is set on an oil pressure testing machine. Rollers are placed between the supporting frame and the testing machine bed, in order to allow the supporting frame to move horizontally. The vertical load supplied by a testing machine is distributed equally among the tops of the four upper columns, being kept constant so that the column force is about 18% or 35% of the yield load of a column. Horizontal force is slowly applied to the upper beam-to-column connetion by an oil jack which was fixed on the supporting frame. The horizontal displacement of the specimens is measured by means of dial gauges and the strain distribution of the members are measured by wire strain gauges.

Throughout the tests, no out-of-plane deformation nor local buckling phenomenon was observed.

It is observed that the restoring force characteristics greatly depend on the magnitude of the vertical load. The maximum horizontal load, applied at the top of a frame, is found to be nearly 10~15% larger than that predicted by the elastic-perfectly plastic theory which takes account of the axial forces of the columns. The stability limit displacement at which a frame becomes unstable is about 1.5/100 times that of the column height.

Experimental Studies on Frames under Horizontal Loading

By Minoru WAKABAYASHI and Bunzo TSUJI

Disaster Prevention Research Institute Annuals No. 10A, March, 1967,
pp. 431–437 (in Japanese).

Abstract

In order to clarify the restoring force characteristics of structures, the load-displacement curves should necessarily be known in repeated loadings as well as in monotonous loading. Some experiments are conducted here using mild steel frames with wide flange sections. Three kinds of frames are tested, which are respectively one-span two-storied frames without bracing, with K-truss type bracings and with diagonal bracings. To prevent lateral buckling prior to the overall collapse in the plane of the frames, two identical frames are connected at several points to form a specimen. Repeated horizontal loads are applied statically at the top of the column in such a way that the horizontal deflection amplitude increases at each half loading cycle.

The shape of the horizontal load-displacement curve of the frames without bracing differs from that of frames with bracings. For the frames without bracing the curve shows a softening type and spindle shapes. The slope of the curve in the process of unloading is nearly equal to the initial one even when the deflection amplitude increases. Bauschinger effect is observed and the yield load gradually decreases. The braced frames show very complicated hysteresis loops under repeated loadings, as a result of the buckling deformation of the bracings and the residual stresses which are induced in the loading history. At the small deflection amplitude unstable equilibrium phenomenon appears after the buckling of the compression bracing. On the contrary, with an increase of the deflection amplitude the unstable phenomenon disappears and the curve shows a softening type and spindle shape. In this case the slope of the curves at unloading deteriorates from the initial one, and the yield load decreases gradually with the increase of the deflection amplitudes. This is caused by the deterioration in the axial stiffness of the bracing due to buckling deformation. The capacity of energy absorption should be large from the view point of the aseismic design of structures. The relation between the equivalent viscous damping coefficient ratio ν_{eq} and the deflection amplitude is deduced from the load-displacement curves. In the case of the frames without bracing, the value of ν_{eq} grows almost linearly with the increase of the deflection. The frames with bracings have a large value of ν_{eq} even under small deflection, but the value does not increase as much as in the frames without bracing.

An Experimental Study of the Buckling Behavior of ⌐└-Angle Sections

By Minoru WAKABAYASHI, Akira ISHIDA, Taijiro NONAKA and Osamu KOSHIRO

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 439–450 (in Japanese).

Abstract

An experimental study is made of the buckling strength and behavior of composite⌐└-sections under central thrust. Two angles constitute a specimen, being connected with each other by bolted or welded joints at equal distances. A total of thirty specimens were tested using L-50 mm × 50 mm × 6 mm and L-65 mm × 65 mm × 6 mm of high tensile steel. The first group of specimens was composed of $2L_s$-50 mm × 50 mm × 6 mm, and had welded joints. The second group was composed of $2L_s$-50 mm × 50 mm × 6 mm, and had bolted joints; the third group L-50 mm × 50 mm × 6 mm or L-65 mm × 65 mm × 6 mm, and bolted joints. It was observed that bending, torsion or local deformation primarily caused buckling in the composite section. Deformations of specimens were measured by dial gauges and wire strain gauges. In the first and second groups, the longer specimens buckled in bending, and the shorter specimens in the coupled action of bending and torsion. In the third group, torsional buckling was seen more than in other groups. The buckling strength of the composite specimens was generally lower than that predicted theoretically for single members with the same bending and twistng stiffness as specimens (upper bound). However, if a composite⌐└-section is regarded as two separate angles, each under central thrust, lower but closer buckling strength of specimens, is predicted (lower bound). For the longer specimens, the buckling strength of the first group was observed to be approximately equal to that of the second group; for the shorter specimens, the buckling strength of the first group was higher than that of the second group. It is considered that the differences between the two groups are due to the rigidity between welded and bolted joints. In the first group, the inelastic buckling strength is higher than the upper bound theory, which assumed the proportional limit of 60% of the yield stress. An approximate value of the proportional limit may be about 60 to 80% of the yield stress.

It is concluded that in a composite⌐└-section the joints should be made rigidly enough to restrain the torsion of each angle. Then, such columns will possess at least the buckling strength predicted by the lower bound theory.

Studies on Structural Stress Analysis Using a Model of Plastics, Part 1 ···Some Preliminary Tests···

By Minoru WAKABAYASHI, Taijiro NONAKA and Takeshi NAKAMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 451-465 (in Japanese).

Abstract

Some preliminary tests are performed to obtain fundamental data, using plastics, for the experimental stress analysis of shells. In the category of plastics, Acrylite polymer was selected as the one having a large proportional limit, uniformity of thickness and the advantage that the pieces can be cemented together without difficulty by liquid monomer. Its elastic characteristics are obtained by tensile tests, bending tests and torsional tests of a rectangular prism. It is found that approximately Young's modulus $E=28{,}000\ kg/cm^2$, the modulus of elasticity in shear $G=10{,}000\ kg/cm^2$, and poisson's ratio $\nu=0.38$. It is noted that the relation $G=E/2\ (1+\nu)$ gives $G=10{,}100\ kg/cm^2$. These values were also checked by a plate deflection test. An appreciable observation is that Young's modulus depends to a considerable extent on the temperature condition of the laboratory.

Although progress of the deformation due to lapse of time is not independent of the load, in the range of this investigation, about 98.5% of the total deformation occurred with in the three minutes after a constant load was given. Young's modulus observed from wire strain gauges is appreciably larger than that from traveling microscopes; the extensional rigidity of the combination of wire strain gauges and the gauge cement heightens the apparent rigidity of the material.

In order to measure curvature, a curvature gauge is made of a dial gauge or of a differential transformer. It seems that the curvature gauge may be conveniently used for a general stress analysis of structures subjected to bending deformation.

A trial test is performed to examine the test techniques developed here as the first step in the application to actual structures. A pressure vessel is experimentally, analyzed attention being paid to the observation of the behavior in the circular cylinder part of the model specimen. The circular cylinder part is made by pressing a sheet of Acrylite into a mold with the shape of a circular cylinder after heating up to about 150°C for softening: Thereafter two edges along a generator are cemented together with Acrylite monomer. The circular cylinder part and a bottom disk are also cemented with Acrylite monomer. The inner pressure is given by an air compressor. A reasonable agreement is seen between the experimental values and the results of the theoretical analysis.

An Experimental Study on the Inelastic Behavior of Steel Frames Subjected to Vertical and Horizontal Loading

By Minoru WAKABAYASHI, Taijiro NONAKA and Chiaki MATSUI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 17, Part 1, July, 1967, pp. 27–48 (in English).

Abstract

Normal building structures are subjected to wind and earthquake forces as well as dead, live and snow loads. The latter act vertically and more or less constantly, while the former act basically in a horizontal direction and vary with time and space. Hence the strength of a structure hinges on the behavior of the structural frame under constant vertical loads and varying horizontal loads. The existence of vertical loads somehow induces the unstable feature of a structure. This phenomenon becomes more important as the structure gets higher, so that the vertical loads increase. Therefore investigation of the behavior of a structure under such conditions is important for the establishment of a design method for tall buildings is imminent. In this paper, experimental results for one and two story steel frames are described and compared with the theoretical predictions.

The test program consisted of eight specimens of one bay rectangular frames, and was composed of two series, each containing four specimens, Series I for one story frames and Series II for two story. Test frames were made by welding beams and columns of mild steel wide-flange sections together. They were approximately 1/4 scale models of the prototypes. In order to prevent out-of-plane deformation, two identical plane frames were connected parallel to each other to form a specimen. The ratio of the column height to the radius of gyration and the beam-to-column stiffness ratio are the representative values of multi-story frames in this country. The magnitude of the vertical loads was decided so that it had approximately the same proportion to the yield load of the columns as in a lower story of an actual multi-story frame. In this experiment, constant vertical loads were applied symmetrically at the top of the upper columns by an oil pressure testing machine. Horizonal force was applied to the beam-to-column connection of the upper story by an oil jack.

It is observed that large vertical loads have induced a significant reduction in the restoring force or unstable character in frame behavior, indicating the importance of dead loads for the horizontal restoring force in tall frames.

The elastic-plastic behavior of the frames reasonably well predicted, until the arising of the mechanism state, by the slope-deflection method taking in to consideration the axial forces, when the formation of plastic hinges was considered. A rough, yet rational, inclusion of the strain-hardening effect in the analysis showed general agreement on the overall behavior of a frame with the experimental results.

Some Interaction Effects in a Problem of Plastic Beam Dynamics, Part 1. Interaction Analysis of a Rigid, Perfectly Plastic Beam

By Taijiro NONAKA

Journal of Applied Mechanics, Trans. ASME,
Vol. 89, 1967, pp. 623–630 (in English).

Abstract

An analysis is presented to determine the permanent deformation of a rigid-plastic clamped beam with constraints against axial displacements at the ends. The beam carries a concentrated mass at its center and is subjected to large impulsive loading at the mass. Plastic interaction is considered for the combined action of bending moments, axial forces and shearing forces, based on a fixed yield surface. The existence of axial constraints is visualized in an interior span of a beam on many supports. Shearing deformation is concerned with large transverse loads. The analysis follows the basic principles of the theory of dynamics and plasticity; the flow rule, or the normality rule, is satisfied in the process of deformation. The problem is solved analytically, and the final deformation has also been found for a clamped beam without axial constraints, simply from the results for the fully clamped beam. The effects of shear and axial forces are discussed in general terms.

The basic assumptions are that the beam is composed of rigid, perfectly plastic, ductile material, and that the loading is strictly impulsive. It is also assumed that the deflections are small enough so that changes in directions of stress resultants are negligible, although finite deflections are considered. The yield surface is approximated as having the form of a parabolic cylinder in the stress resultant space.

Various patterns of deformation are found to occur, according to the beam dimensions. Ordinarily, shearing and bending deformations predominate at early stages of deformation, possibly with finite plastic zones near the clamped ends. If constraints against axial motion are present, axial forces come into effect as deformation proceeds so that the interaction of bending and extension plays an important role. When the beam acquires a deflection of the order of the beam depth or greater, deformation is primarily governed by the axial force, and the axial constraints reduce the deflection by a considerable amount; whereas the shear effect is found to be small for ordinary beam dimensions with compact cross section unless the attached mass is small compared to the beam mass. The shear effect becomes larger for short beams and noncompact sections subjected to impulsive loading. Unless the attached mass is small, the major portion of deformation occurs in a one-degree-of-freedom mode, the two halves of the beam rotating about the supports.

Some Interaction Effects in a Problem of Plastic Beam Dynamics, Part 2. Analysis of a Structure as a System of One Degree of Freedom

By Taijiro NONAKA

Journal of Applied Mechanics, Trans. ASME,
vol. 89, 1967, pp. 631–637 (in English).

Abstract

A theoretical study is made of the permanent deformation of a clamped beam with constraints against axial displacements at the ends. The beam carries a concentrated mass at its center and is subjected to large transverse impact loading at the mass.

In the preceding paper, Part 1, it was shown from the results that the shearing deformation is small for compact cross-sections, unless the span-depth ratio is small and the attached mass is small in comparison with the mass of the beam. It was also found that the major portion of deformation takes place in a one-degree-of-freedom mode; i. e., the pattern in which two halves of the beam rotate about the clamped ends. In this paper, Part 2, therefore, the one-degree-of-freedom is assumed. Possible existence of fine plastic zones and shearing deformation are ignored. Effects of elastic vibration, strain-rate sensitivity, and the load shape are taken into account in an approximate manner based on the mode assumption of one-degree-of-freedom. Considerations are given to the plastic interaction between bending and extension. The permanent deformation is determined for a rectangular cross-section. It is assumed that, until the string stage is reached, plastic strains are concentrated in small triangular regions of plastic hinges near the clamped ends and the attached mass and that, in the string stage, the plastic regions expand as the deflection increases. The results are also applied by simple modification in a case where the axial constraints are absent.

By comparing the plastic deformation for pure impulsive loading with that for rectangular pulse loading with the same total impulse, it is found that a larger magnitude of load causes larger deformation for the same total impulse, and that the error due to the assumption of impulsive loading is much reduced when the elastic deformation is taken into account. The effect of axial constraints can be neglected if the square of the ratio of the maximum deflection to the beam depth is of the order of less than unity, and the axial constraints reduce the permanent deformation considerably when the deflection is of the order of the beam depth or greater.

Some Interaction Effects in a Problem of Plastic Beam Dynamics, Part 3. Experimental Study

By Taijiro NONAKA

Journal of Applied Mechanics, Trans. ASME,
Vol. 89, 1967, pp. 638–643 (in English).

Abstract

An experimental study is made of the permanent deformation of clamped beams with and without constraints against axial displacements at the ends, in order to check on the validity of the theories presented in the preceding papers, Part 1 and 2. The beams carry a concentrated mass at the center and are subjected to blast loading at the central mass. The test program employs rectangular cross-section beams of constant mass ratio and constant span-depth ratio. A total of thirty specimens of aluminum alloy 6061-T6 and hot rolled mild steel 1020 are tested. A specimen of some nine-inches length is held on a ballistic pendulum through a specimen holder which was designed to obtain the desired boundary conditions. The pendulum served as a means of measuring the applied impulse. The load is produced by detonating an electric blasting cap. The impulse is calculated from the measured values of the amplitude, period and weight of the pendulum. The measuremeut of the load-time relation is not attempted. A fully clamped end condition is produced by means of serrated surfaces which are made of oil-hardened tool steel. For the constraints against rotation but not axial motion, the serrated surfaces are covered by two steel blocks at each support, and teflon sheets are placed beetween the specimen and the steel blocks in order to permit free axial motion.

The beam portion of the specimens have remained essentially straight except for small regions adjacent to the supports and the central mass. The pictures clearly show this deformation pattern, which was assumed in the theory of Part 2. The most significant consequence is that considrable effects of axial constraints are observed both in theory and in the experiment. In general, experimental results for the permanent deformation agree quite well with the theoretical predictions in Part 2, which takes account of the strain rate and elastic effects. A satisfactory agreement is seen for the aluminum specimens.

The rigid-plastic analysis overestimates the deformation, but serves as a first approximation for large deformations.

On Poisonous Gas In A Tunnel (II)

By Yoshikazu WAKAZONO, Terushige OGAWA and Chugoro SATO

Annuals, Disaster Prevention Research Institute, Kyoto University
No. 10A, March, 1967, pp. 385-389 (in Japanese).

Abstract

The health hazard of poisonous gases, such as products of explosives or exhaust gases from gasoline or disel-driven equipment, is a relatively important problem in underground operations. However, little attention has been paid to products of explosives. In order to obtain fundamental data for preventive measures against accidents caused by poisonous gases in underground blasting operations, we analysed the toxic gases from the detonation products of dynamite in the Shin-Fukazawa raiway tunnel and Kiso closed conduit which were under construction.

We measured the concentration of carbon monoxide (CO) and nitrose (NO, NO_2 etc.) at the place of blasting by the Kitagawa method and by the phenol-disulfonic acid method, We examined the effect of ventilation or blasing design on the concentration of toxic gases from blasting,

Through these measurings and testings, we concluded as follows:

(1) Good ventilation should be provided, because the amount of carbon monoxide and nitrose in a tunnel exceeds the respective allowable concentrations near the place of blasting for some time after the last blasting.

(2) It must be noted that, if the blasting effect is not sufficient, the amount of poisonous gas produced by blasting increases considerably due to the incomplete detonation of the dynamite.

Noise And Vibration From Blasting

By Ichiro ITO, Yoshikazu WAKAZONO, Koichi SASA, Kenji SHIGEMATSU, Terushige OGAWA and Masashi NAKANO

Suiyōkwai-Shi, Transactions of the Mining and Metallurgical Alumi Association Kyoto University, Vol. 16, No. 3, March, 1967, pp. 127–139 (in Japanese).

Abstract

In order to increase the knowledge of public damage due to blasting, both ground motion and noise caused by blasting were measured. The main results obtained are briefly shown below.

1) The ground motion caused by the explosion of 40 kg of confined dynamite at a point about 500 m from the blasting point was smaller than the vibration limit at the residential zone established by the provincial government.

2) The magnitudes of noise at the same point caused by surface explosions of 20 kg and 5 kg dynamite charges with small amounts of mud covering were about 120 db and 110 db respectively, and the magnitude of the noise was in proportion to the square root of the charge weight.

3) Placing water in a plastic bag on an explosive was effective for the reduction of the noise.

Studies On Underwater Blasting
—On The Clearing Of Underwater Obstructions—

By Yoshikazu WAKAZONO and Masashi NAKANO

Bulletin of the National Pearl Research Laboratory,
Vol. 12, Nov., 1967, pp. 1458-1466 (in Japanese).

Abstract

Studies on underwater blastting have widely developed of late. Furthermore, the clearing of underwater obstructions scattered over fishing-ground has been devised. The purpose of this plan is the reformation of worn-out pearl ground by enabling the tide to flow more easily. During the year before last, an underwater dam across one of the inlets in Ago Bay was cleared away.

On this occasion, the authors made studies on underwater blasting to remove this obstruction. Using explosives they blew of the underwater dam.

They conducted preliminary blasting in January and the main blating in March, 1967. From the experimental data of the preliminary blasting, they recognized that the surface blasting method was very effective and so they employed it for the main blasting.

They stuck exploives one after another on the protruding parts of the dam from aboard a sampan and ignited them by electric caps. For this blasting they used a special explosive, Kozumite No. 23, which was produced for underwater blastng.

The main blasting was completed in five days. The underwater dam was almost perfectly cleared away and the flow of tide at this place became pretty fast.

From the above experimental data, it was found that the blasting coefficient C, the ratio of the amount of explosives consumed to the amount of rocks removed, was 0.61. This value is one of the standards when a calculation is made of the amount of explosives consumed during underwater surface blasting.

They also recognized that the surface blasting method is easier and extremely effective for underwater rock blasting. It was further recognized that one can achieve sufficient blasting effects both at a low cost and in a short period of time by this method.

Studies On Underwater Blasting
—On The Shock Wave Due To Underwater Blasting—

By Yoshikazu WAKAZONO and Terushige OGAWA

Bulletin of the National Pearl Research Laboratory,
Vol. 12, Nov., 1967, pp. 1467-1486 (in Japanese).

Abstract

Recently many underwater operations have been in need of underwater blasting. But there are difficult problems in underwater blasting. In order to increase knowledge for solving these problems, we made fundamental experiments described below in Ago Bay.

(1) On damage to fish or shell-fish due to the shock or pressure wave

Blasting with 7 kg of dynamite, we measured the underwater peak pressure by piezo-electric gauge at various distances from 5 m to 93 m, and observed the damage to the young yellowtails, top-shells, ear-shells and mother of pearl placed at distances of from 10 m to 250 m from the blasting point.

Through this meauring, we obtained results showing that the peak pressure was essentially identical with the data obtained by Kirkwood-Brinley's formula. From the results of these observations we came to conclusion that the young yellowtails were damaged by a peak pressure of 5 kg/cm^2 and that shell-fish, except top-shells, were not damaged.

(2) On the pressure-time curve of the pressure wave

In order to obtain fundamental data about the exploding mechanism, we measured by piezo-electric gauge the pressure-time curve of underwater pressure wave caused by the explosion of Composition C-3, Kozumite No. 23, Dynamite, TNT-Slurry, Al-Slurry and ANFO.

The results obtained were that Composition C-3 and Kozumite No. 23 showed sharp peak pressure in the pressure-time curve of the pressure wave, but that the other explosives showed flat peak pressure. This seemed to be concerned with the fact that Composition C-3 and Kozumite No. 23 were highly explosive and gave good results in underwater blasting.

Spectra of Wind Pressure Fluctuations on Structures

By Hatsuo ISHIZAKI and Changgoo HUH

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16. Part 3, Feb. 1967, pp. 1-9 (in English).

Abstract

Wind pressure fluctuations on structures have very complicated characteristics, as the wind itself changes its direction and speed; besides, the wind around a structure is disturbed by it. Up-to-date, little data on pressure fluctuations observed on structures has been obtained. In order to get imformations about the wind loads on structures, wind pressure fluctuations on the walls and roofs of an actual house were measured. The measurements were carried out in seasonal wind at the Shionomisaki Wind Effect Laboratory of Kyoto University on Jan. 23 rd and Mar. 17 th, 1963. The average wind velocity was 5 m/sec to 18 m/sec at a point 10 m above ground level and the windward side of the house was an open field. The power spectra of wind pressure fluctuations were made from the test data. The results showed that the power spectra on the windward walls were similar to those of free natural wind. On the other hand it was noted that the pressure fluctuations on roofs or eaves showed peaks near the period of 0.2 sec to 0.3 sec. These will be due to the vortices broken out periodically from the roofs or eaves and the wind pressure spectra are affected more by the shape of house than by the turbulence in natural winds. The period of 0.2 sec to 0.3 sec at which the power spectra take peak values, is expected to be shorter as the wind speed becomes larger.

Consequently, we conclude that the character of the dynamic effects of wind pressure on structures is mainly governed by shape of structures, except on windward walls. The dynamic behavior of wind pressures are varies at the surface on each part of the structure. It will be better that the natural period of the structural component is designed to be apart from that of the predominant period of pressure fluctuations.

On the Gust Effects of Wind Pressure on Walls

By Hatsuo ISHIZAKI and Tatsuo MUROTA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 355-360 (in Japanese).

Abstract

Wind pressure measurements on walls of an actual house were made to investigate the gust action of wind pressure on walls. The house experimented was gable-roofed and 5.8 m × 7.9 m in plan, and the height of the eaves was 3 m above the ground. The wind pressures were observed at 5 points on the walls and at a point on a pole 17.5 m in front of the north side wall. The pressure gauges used were the bellow type and pressures were induced to the electric quantity by the differential transformer. The average wind speed during the observations was 15−16 m/sec.

The gust factor G is proposed by Mitsuta as

$$G=\left(\frac{S}{D}\right)^{-p}$$

where S is the sampling duration time of the peak gust and D is the sampling duration time of the mean wind velocity. Assuming that the wind pressure is proportional to the square of the wind velocity,

$$G_p=\left(\frac{S}{D}\right)^{-2p} \qquad (1)$$

where G_p is the gust factor on wind pressure.

Analysing the wind pressure records, the relations between the gust factor G_p and the sampling duration time of peak gusts or the values of p in eq. (1) are obtained.

The results are as follows:

(1) The gust action on walls is not so intense as that of free natural wind, which means that wind pressure fluctuations having higher frequencies decrease on walls.

(2) The gust action on walls near eaves or parallel to the wind direction is smaller than that on walls facing the wind.

The Response of Steel Tower Structures to Wind Gusts

By Hatsuo ISHIZAKI and Sumio KAWAMURA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 367–375 (in Japanese).

Abstract

The response of line-like structures such as steel towers to gusty wind has been obtained by Davenport using the stochastic process. To determine the spatial extent of gusts, it is necessary for structural purposes to refer to the narrow band spatial correlation between velocities or pressures at different points. The cross-correlation function is in fact a complex quantity consisting of the real and imaginary or quadrature part, which measures the correlation between the velocity fluctuations at the two points with a phase separation of 90°.

The coherence, which is the sum of the two componential square, has been used instead of cross-correlation by Davenport.

It is proved that the method using the coherence is the upper bound. The lower bound of the cross-correlation spectrum is introduced. From a practical point of view, the response of line-like structures to gusty wind may be estimated fairly well by these two bounds.

The Effects of Rain or Water Drops on Storm Damages

By Yasushi MITSUTA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 377-383 (in Japanese).

Abstract

The effects of rain or water drops on storm damages are studied. In Japan the causes of storm damages are mainly typhoon winds, and heavy rainfall is acompanied by severe winds near the eye wall of the typhoon where the wind is at its maximum intensity. Therefore this problem is especially important in this country.

The increase of mean air density from rain water contained in the air is studied in the first half of the paper. The maximum rainfall intensity observed in Japan is 56 mm/ 10 min, and the maximum expected rainfall intensity would be of the order of a thousand mm per hour. Supposing the distribution of raindrop diameter to be that of Marshall and Palmer the increase of mean air density is estimated, the results of which are shown in Fig. 1. As is clear from this figure, the increase is less than a few per cent of the density of dry air, which for practical purposes can be neglected, except in special cases.

The second effect of rain is the direct destructive effect of the particular fast moving rain drop in the storm, which is discussed in the last half of the paper. The possible maximum radius of a rain drop in the air is about 4 mm after Komabayashi et al. The mass is about 0.3 gr in such a case. The time constant of the rain drop movement in the changing wind speed is discussed. The time constant of the maximum rain drop is estimated to be about 1 sec. Therefore it will respond to the gust with a duration of about 2 sec or more. The maximum possible gust speed of such duration might be 90 m/ sec or so, and the maximum force exerted on the surface exposed to the wind would be of the order of 50 kgr/cm^2, but its duration is only about 10^{-6} sec or so. This effect cannot be directly related with the causes of wind disasters. But the dropping off of paint from high stacks or towers in a typhoon storm might be a type of disaster which can be related to this effect.

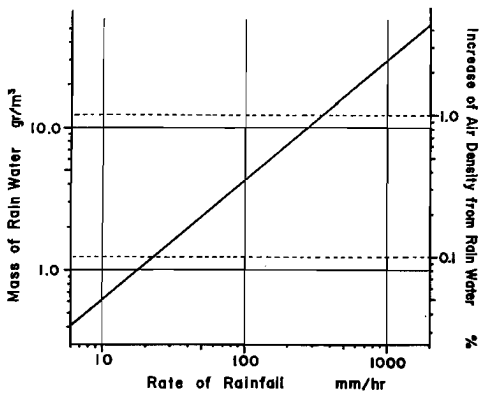


Fig. 2 Variation of mass of rain water in the air with rate of rainfall contained.

A New System for Measurement of Turbulent Transfer Processes

By Yasushi MITSUTA, Tatsuo HANAFUSA and Ken SAHASHI

The Collection and Processing of Field Data (Proceedings of the Symposium at Canberra, 1966), Nov., 1967, pp. 45–54 (in Fnglish).

Abstract

The necessity of measuring the vertical turbulent transport of momentum, water vapor, sensible heat and other physical entities in the boundary layer has been recognized. However no adequate method or instrument has appeared, except for a few examples employing classical techniques of measurement. The goal of the present study is to develope a direct meothd of determining turbulent transport of physical entities by the use of the recently developed techniques of sonic anemometer-thermometer and infrared hygrometer. Though the final form of the system has not yet been completed, each component has already been developed and used in field experiments.

The vertical turbulent transport of the physical entity is defined by

$$F = \overline{(\rho w)'x'}$$

where ρ is air density, w the vertical wind compenent and x the concentration of the entity under consideration. For the measurement of the vertical mass flow ρw, the sonic anemometer developed by one of the present autuors is used. As for the sensor of the concentration of the physical entities, the sonic-anemometer for momentum, sonic thermometer for air temperature and infrared hygrometer for water vapor are employed. All of them were recently developed for this study by the present authors. For computing the transport, analogue real time processing is proposed.

Before completion of the whole system, test observations using the sensors were carried out to obtain the design details. The results of the observations made with the one dimensional sonic anemometer-thermometers with sound path of 0.5 m are presented. Evaporation or water vapor flux measurement was done by the use of dry and wet bulb thermocouples in place of the infrared hygrometer which was not completed. The results were compared with the results obtained by other methods of evaporation estimate. Sensible heat flux measurements were made at two different heights at the same time. The results of momentum flux measurements were compared with the reults of the drag-meter measurements. The results of these test observations are not quite satisfactory but are enough to obtain fundamental materials of design details to complete the system.

On the Compressive Strength and Ductility of Steel in the Heat-affected Zone of Welded Joints

By Ryo TANABASHI and Kiyoshi KANETA

Transactions of the Architectural Institute of Japan, Extra,
Oct., 1967, p. 465 (in Japanese).

Abstract

An experiment has been carried out on the compressive strength and ductility of steel specimens under static, repetitive loading. The specimens were made from the base metal, weld metal and the heat-affected zone in buttweld joints of steel plates. Materials were JIS SM50B and YES36A—both high tensile steel used for building structures and bridges.

Compression specimens were made to a cylinder—37.5 mm long and 12.5 mm in diameter—cut from the welded steel plates of 25 mm in the thickness. For the static tests, an Amsler-type testing machine, of 20 ton maximum capacity, was used. The strain rate was controlled manually.

From the results of the experimental study, conclusions have been drawn as follows:

1) The stress-strain diagram plotted from the compression tests presented somewhat remarkably the existense of the "contained plastic flow" zone, whereas the tension test specimens in general showed the ideal elastic-plastic stress-strain relationship.

2) The heat-affected zone specimens had slightly larger values of yield point stress than those of the base metal specimens. The test pieces taken from the weld metal also had higher yield points than the base metal, but the results in this case were less coincident.

3) Effect of the repetitive loading on the behavior of the three kinds of specimens in the "unrestricted plastic flow" zone of the stress-strain diagram was not pronounced. Namely, the strength and ductility of the specimens were not strikingly affected by a number of cycles of loading and unloading until the strain hardening began to occur.

4) Strain hardening was observed at the strains of the specimens ---1.1 % for the base metal, from 1.0 to 1.18% for the weld metal, and from 1.35 to 1.72% for the heat affected zone specimens. Clearly, the ductility of the heat-affected zone specimens was well recognized.

Non-stationary Response of the Linear System to Random Excitation

By Takuji KOBORI and Ryoichiro MINAI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 16, Part 2, Jan., 1967, pp. 37-80 (in English).

Abstract

In relation to the statistical design method of anti-earthquake structures for moderately intense excitations, the basic studies on the statistical quantities, such as the covariance and spectral density in the non-stationary stochastic process, are described and the input and output relations of such quantities in the case of a multi-input and -output, linear discrete system having time-variant coefficients are presented.

As the basic statistical quantities in the time and frequency domain, the local covariance matrix and the local spectral density matrices are considered in this paper. First, the local co-variance matrix is defined ae the product of a two-dimensional cutoff operator and the co-variance matrix in a non-stationary stochastic process.

Then, the two-dimensional local spectral density matrix and the several kinds of one-dimensional local spectral density matrices are introduced by defining them as the double and single Fourier transform of the local co-variance matrix, respectively. It is found that the appropriately defined one-dimensional spectral density matrices containing a time variable have the meaning of the power spectral density matrix in the non-stationary stochastic process in the sense that the integral of these quantities over the finite time domain results in the local energy spectral density matrix defined in the square time domain. And also, it is shown that as a limiting case, the one-dimensional local Hermitian spectral density matrix presented in this paper is reduced to the spectral density matrix introduced by D. G. Lampard. Moreover it is shown that the local spectral density matrices are expressed as the weighted averages of the corresponding total spectral density matrices associated with the full time domain.

For the general case of a multi-input and -output linear discrete system having time-variant, complex-valued coefficients, the input and output relations of the local co-variance matrix and the one- or two-dimensional local spectral density matrices are presented. And it is shown that as a special case of linear discrete system having time-invariant, real-valued coefficients, the input and output relation of the two-dimensional total spectral density matrix is reduced to the relation presented by J. S. Bendat. As an example of the non-stationary input process most applicable to earthquake engineering, the quasi-stationary random process introduced by V. V. Bolotin as well as the locally stationary random process presented by R. A. Silverman are considered, and the basic statistical quantities of the output of a linear system subjected to these random inputs are estimated.

Observations of the Matsushiro Earthquakes —On the Response Characteristics of a Building Structure and Neighbouring Ground (First Report)—

By Takuji KOBORI, Ryoichiro, MINAI, Yutaka INOUE, Yoshihiro TAKEUCHI and Teruo KAMADA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 10A, March, 1967, pp. 221-233 (in Japanese).

Abstract

It is very important for earthquake engineering to clarify the characteristics of earthquakes and the vibrational properties of a coupled ground-structure system by means of the observation of responses of ground and structures during earthquakes. For the purpose of a study on the earthquake response of a coupled ground-structure system, we observed the responses of a two-story, reinforced concrete building structure and of the ground near the structure caused by Matsushiro Earthquake Swarm.

The power spectral densities of these various responses are evaluated from Fourier transforms of the digitized velocity responses simultaneously recorded on each floor of the structure and on the ground near the structure. Also for the many earthquake responses of the structure and the ground, average velocity response spectra are calculated by an analog computer.

As a result of these spectral analyses, the following remarks can be made on the vibratational characteristics of the ground and the structure.

(I) Two horizontal components of motions perpendicular to each other are similar together and have a peak value at two or three cycles per second in the power spectral densities.

(II) The other smaller peak of the power spectral density of the horizontal component is found at ten cycles per second.

(III) The power spectral density of the vertical motion of the ground has a relatively smoothed variation of power with frequency, although at five cycles per second it has the largest power.

(IV) The coupled system seems to have a fundamental natural period of about 0.15—0.3 seconds, and the lower modes of rocking vibration seem to be predominant over the other vibration modes of the coupled system during main shocks.

(V) If the distance away from the structure is more than thirty meters, the response of the ground is scarcely affected by the dynamical coupling of the structure.

Linearization Technique for Evaluating the Elasto-Plastic Response of a Structural System to Non-stationary Random Excitations

By Takuji KOBORI and Ryoichiro MINAI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 235-260 (in Japanese).

Abstract

In the aseismic design of structures for moderately intense earthquakes having a large frequency of occurrence, it is reasonable to take a comparatively small safety factor with regard to the earthquake excitations, the safety factor with respect to the structural response being satisfactorily large, so that the earthquake reponses of a structure may remain in the elastic or almost elastic range. Along this direction, it is necessary to suppose pertinently the statistical model of earthquake excitations according to the seismicity and the soil conditions of the construction site of a structure, and to analyze the dynamic random response of a ground-structural system which behaves in the elastic or elasto-plastic range during the earthquake excitations.

In this paper, as a statistical measure of the aseismicsafety of a ground-structural system, the expected number of exceeding the response level is considered, and the analytical expression of this quantity is presented supposing the Gaussian non-stationary random process. And, in order to estimate the basic statistical quantities of the non-stationary random process which are required for evaluating the above-mentioned statistical measure of aseismic safety, a linearization technique for obtaining the non-linear, non-stationary random responses is presented for an elasto-plastic dynamic system having bi-linear hysteretic characteristics, subjected to the Gaussian non-stationary random excitations.

From the expected number of exceeding the response level per unit time, the analytical expressions of the average frequency as well as the probability distribution of extremal amplitude of the Gaussian non-stationary random process are obtained. And then, by making use of these quantities, the equivalently linearized parameters of a stable bi-linear hysteresis loop are determined according to the least mean square error criterion. Based upon this linearization technique, the step by step integration procedure for the numerical evaluation of the average vectors and the covariance matrices of the responses and their time derivatives of a multi-input and -output discrete system having the bi-linear hysteretic characteristics is derived assuming the Gaussian non-stationary random inputs and non-zero random initial conditions.

Earthquake Response of a Structure Considering the Effect of the Ground Compliance (3rd Report)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE and Teruo KAMADA

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 261–281 (in Japanese).

Abstract

It has been widely recognized that a structural response subjected to strong earthquake motion is much influenced by the dynamic characteristics of the ground and that it is important and necessary to estimate reasonably the effect of the ground on the earthquake response of a structure. This report is a part of non-stationary, elasto-plastic response analyses of a structure coupled with ground to random earthquake excitation by means of an electronic analog computer. The dynamic characteristics of a foundation on elastic ground are expressed as a rational transfer function approximately determined from the theoretical or experimental dynamical ground compliance of the foundation.

Basic methods of the analyses are as same as those adopted in the preceding papers, however, in this paper, the above-ground structure is simply supposed to be a single-degree-of-freedom, elastoplastic system having a bi-linear hysteresis loop to clarify the effect of the most significant system parameters on the earthquake response of the ground-structure system. The following quantites are selected as the significant parameters which concern the degree of coupling between the structure and the ground. m_0: mass ratio of the substructure and above-ground structure, m_H: mass ratio of the substructure and elastic ground, λ: fundamental frquency ratio of the above-ground structure and substructure. These are varied in a wider range than in preceding papers.

The maximum nondimensional displacements of the system are considered and they are compared with those in the case of a fixed foundation and in a case without the boundary layer which represents the elasto-plastic ground surrounding the substructure. The following remarks are mainly pointed out:

(1) The most effective parameters on the earthquake response of an above-ground structure are, of course, intensity and frequency parameters of earthquake excitation, but the effect of dynamic behaviour of ground is highly important.

(2) When the mass ratio m_0 is large, the boundary layer shows large plastic behaviour, which has the effect of decreasing the relative displacement of the above-ground structure.

(3) The greater the mass ratio m_H becomes, the larger the structural response occurs. This is consequent on the decrease of the equivalent viscous damping of elastic ground with increase of m_H.

(4) Fundamental frequency ratio λ greatly affects the response of elastic ground.

Dynamical Ground Compliance of a Rectangular Foundation on a Semi-Infinite Elastic Medium (Part 1)

By Takuji KOBORI, Ryoichiro MINAI, Tamotsu SUZUKI and Kaoru KUSAKABE

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 283-314 (in Japanese).

Abstract

As a basic study to examine the effects of soil ground on the earthquake response of structures, it is intended in this paper to investigate the dynamical characteristics of a rectangular foundation on a semi-infinite elastic ground.

Based on the elastic wave propagation theory, we obtain the analytical expression of "Dynamical Ground Compliance" of a rectangular foundation, on which are exerted the four kinds of harmonic disturbing forces——vertical, horizontal, rotational and torsional excitations. It is defined as the ratio of the foundation displacement to the disturbing force, and represents the transfer function of the elastic ground. As the solution is expressed by an improper, infinite, double integral, containing the Rayleigh pole which is the real root of the frequency equation, we must evaluate this integral in the complex plane.

Based on the numerical results, the properties of Dynamical Ground Compliance are pointed out as follows:

(1) Depending on the kind of disturbing force, the shape and dimension of the foundation area, and the ground constants (Poisson's ratio, shear rigidity, and density), it generally represents the dynamical characteristics of the foundation on a semi-infinite elastic ground.

(2) It is expressed by the complex valued function of frequency, the imaginary part of which is concerned with the energy diffusion phenomenon caused by the irreversible wave propagation from the source at the surface to the elastic ground.

(3) Dynamical Ground Compliance in the case of vertical translation (or rotation), as a whole, has a similar tendency to that of horizontal translation (or torsion). This result corresponds to the fact that, in the sense of vibration phenomenon, there is no essential difference between these two cases.

(4) The residue term at the Rayleigh pole is concerned with the energy diffusion phenomenon caused by the Rayleigh surface wave. The ratio of the residue term to the imaginary part may be considered as a measure indicating the possible occurrence of the Rayleigh wave. This ratio in the case of vertical translation (or rotation) is much larger than that of horizontal translation (or torsion).

(5) The value of Dynamical Ground Compliance varies widely with frequency. This fact suggests that we must generally consider the spring-dashpot-mass system having the variable coefficients of frequency as the dynamical model of the foundation on an elastic ground.

Dynamical Ground Compliance of a Rectangular Foundation on an Elastic Stratum over a Semi-Infinite Rigid Medium (Part 2)

By Takuji KOBORI, Ryoichiro MINAI and Tamotsu SUZUKI

Annuals, Disaster Prevention Research Institute, Kyoto University,
No. 10A, March, 1967, pp. 315-341 (in Japanese).

Abstract

In the previous paper, one of the authors discussed the "Dynamical Ground Compliance" of a rectangular foundation on a semi-infinite elastic medium in order to clarify the dynamical effect of the sub-soil ground on the earthquake response of structures. This compliance is expressed by the ratio of the foundation displacement to a harmonic disturbing force, and corresponds to the transfer functon of the ground surrounding a foundation.

At the first step to investigate the dynamical properties of the sub-soil ground considered as a stratified medium, we discuss, in this paper, the Dynamical Ground Compliance of a homogeneous, isotropic, elastic stratum with constant thickness over a semi-infinite rigid medium in the cases of vertical, horizontal and rotational excitation. The analytical expression is obtained herein using almost the same method based on the three-dimensional wave propagation theory as in the previous paper. The numerical evaluation is carried out for the vertical and rotational excitations.

Two types of boundary conditions at the surface between a stratum and a rigid medium are considered; one of them permissible for a free-slide at the boundary surface horizontally and the other unpermissible.

The pronounced characters different from the case of semi-infinite medium are summarized as follows:

(1) We can indicate, first of all, that in the case of a stratum there are three kinds of resonant frequency, corresponding to the natural frequency of an equivalent one-dimensional rod with the same length and similar end conditions as the stratum, to the zero group velocity of some vibration mode, and to the common phase velocity of distinct modes.

(2) Secondly, it can be found that, in the range of low frequency, the diffusive energy, caused by the irreversible surface waves propagated in the radial direction, is extremely small in the case of free horizontal slide at the boundary and does not exist in the other case.

(3) Dynamical Ground Compliance for the stratum having a larger thickness in comparison with the width of a foundation, is similar to that for a semi-infinite medium except for the vicinity of resonant frequencies and low frequency range mentioned as in (1) and (2) respectively.

On the Statistical Method of Determination of the Linear Transfer Function of a Structure (continued)

By Takuji KOBORI, Ryoichiro MINAI, Yoshihiro TAKEUCHI and Masahiro KAWANO

Reports of the Architectural Institute of Japan (KINKI Sub-division), April, 1967, pp. 77–80 (in Japanese).

Abstract

In the preceding paper, two kinds of statistical methods of determing the dynamic characteristics of the linear structuctural system were presented. The first method is based upon the extended expression of the Wiener-Levinson formula for a single-input and-output system to a multi-input and-output system. The second method is derived from the relationshship between the input and output spectral density matrices by considering only the physically realizable condition of the system. In the present paper, a problem which arises in detecting the dynamic characteristics of a linear structural system by the second method is mainly discussed.

In estimating the natural frequencies and the critical damping ratios from the transfer characteristics defined as the ratio of the output spectral density to the input spectral density, which are calculated from the relevant auto-correlation functions, the finite total delay of the auto-correlation functions greatly affects the evaluation of these dynamic parametrs.

To study this problem, the dynamic parameters of a prescribed two-degree-of-freedem system subjected to stationary random excitations are calculated by the second method, supposing three kinds of total delays of the auto-correlation functions. As a result, it is found that the smaller the total delay becomes, the more ambiguous the natural freqency detected is and the more the critical damping ratio is overestimated. As a theoretical consideration of this problem, the analytical expression of the pseudo-spectral density which is defined as the Fourier transform of the sum of the auto-correlation function multiplied by a cut-off operator and a normalizing bias, is considered. The expression of the pseudo-spectral density is obtained as the sum of the convolution integral between the true spectral density and a linearly decaying sinusoidal function and the constant proportional to the normalizing bias multiplied by the same sinusoidal function. When the total delay tends to infinity and the normalizing bias becomes zero, the pseudo-spectral density agrees with the true spectral density.

From this consideration together with the results of the numerical evaluation of the dynamic parameters of the two degree-of-freedom system, it is suggested that the total delay of the auto-correlation function should be made sufficiently large compared to the fundamental natural period, particularly for a system with slight damping characteteristics.

Dynamical Ground Compliance of a Rectangular Foundation on an Elastic Stratum (Horizontal Case)

By Takuji KOBORI, Ryoichiro MINAI and Tamotsu SUZUKI

Reports of the Architectural Institute of Japan (KINKI Sub-division),
April, 1967, pp. 85-88 (in Japanese).

Abstract

In order to investigate the dynamical effect of sub-soil ground on the earthquake response of structures, the authors have attempted to represent the dynamical properties of the ground generally, making use of the "Dynamical Ground Compliance" of a rectangular foundation on a semi-infinite elastic medium. This is a concept defined in the "frequency range" as the ratio of the displacement of a foundation to an exciting force, and thus means the transfer function of the ground surrounding a foudation.

We can often find actual ground that can be regarded as a stratified medium. In this paper, as the first step to investigate the dynamical properties of such a stratified medium, we try to obtain, in the case of horizontal excitation, the analytical and numerical expressions of the Dynamical Ground Comliance of an elastic stratum fixed on a semi-infinite rigid medium according to the same method based on the three-dimensional elastic wave propagation theory as in the previous paper.

The principal results are given as follows:

(1) In comparison with a semi-infinite medium, we can find a distinguishing aspect that the three kind of resonant frequencies exist innumerably. As the stratum is assumed to be a non-dissipative medium and also no waves can propagate from the stratum to the rigid base, so the resonant amplitude becomes infinite.

(2) But we find out the ground property with an apparent attenuating effect, because of the energy diffusion caused by waves propagated in the radial direction. In the case of horizontal excitation, there are two kinds of surface waves in the radial direction—Rayleigh and Love waves. The surface wave of a higher mode appears and the amount of diffusion energy increases when the frequency exceeds a resonance point.

(3) Such an attenuating effect is not found in the frequency range below the lowest resonant frequency correspnding to the fundamental natural frequency of the equivalent shear-type rod with the same lenth and similar end conditions as the stratum.

(4) Dynamical Ground Compliance for the stratum having a larger thickness in comparison with the width of a foundation is similar to that for a semi-infinite medium except in the vicinity of resonant frequencies and the range of low frequency described in (3). This case is, as a whole, similar to the verical case.

Observation of the Matsushiro Earthquakes (III)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE, Yoshihiro TAKEUCHI and Teruo KAMADA

Reports of the Architectural Institute of Japan (KINKI Subdivision), April, 1967, pp. 89–92 (in Japanese).

Abstract

The purpose of the observation of the Matsushiro earthquakes is to obtain useful information on the dynamic behaviour of the actual coupled ground-structure system subjected to natural earthquakes. Through the long period observation at Matsushiro High School, many earthquake records were obtained at each floor level of a two storey reinforced concrete school building and at several points selected on the adjacent ground surface and under the ground.

Althogh these data are now under analysis, some general considerations on the vibrational characteristics of structure and ground have been already done in preceding papers. So, in this paper, the transfer characteristics of seismic waves in the ground are mainly discussed.

According to the results of boring tests at the observation site, the ground consits of very soft clay up to within 18 meters of the ground surface, and there is a thin gravel layer from 18 to 20 meters in depth on top.

By comparing the earthquake records on the ground surface with those at a point 20 meters deep, it is found that during the vertical propagation of seismic waves in the surface layer of 20 meters thickness, vertical component of waves suffers less modificaton on the frequency and phase characteristics than horizontal components. From the power spectral densities of the earhquake records obtained simultaneously at points 1 meter, 10 meters and 20 meters in depth from the ground surface, the vertical transfer characteristics of seismic waves in the surface layer are discussed. It is indicated that there is no remarkable difference between the spectral characteristics at points 10 and 20 meters in depth, but the power spectral density at the point 1 meter deep is amplified in the low frequency range compared with those that are 10 and 20 meters deep.

In the latter half of this paper, a brief discussion is made about the dynamic characteristics of the coupled ground-structure system based on the analyses of earthquake responses of structure. It is shown that the structural system has the effect of increasing the low frequency component as well as decreasing the high frequncy component contained in the seismic waves, and that the fundamental natural frequency of this system is within the range of from two to four cycles per second.

Characteristics of Pseudo-Earthquake Ground Motions (Part 1)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE,
Yoshihiro TAKEUCHI and Masahiro KAWANO

Transactions of the Architectural Institute of Japan, Extra, Oct., 1967, p. 161
(in Japanese).

Abstract

It is important to reasonably suppose the model of earthquake excitations in the dynamic analysis for the aseismic design of structures. However, it may be very difficult to definitely determine the size and origin of future earthquakes at the construction site of a structure, and also to estimate statistically the spect ral characteristics of the earthquake which depend on the frequency character istics of excittation associated with the origins and the modes of the reflections and refractions caused by the complicated geological structures in the pass of seismic wave propagation. Therefore, the reasonable site characteristics of earthquakes must be estimated from the engineering point of view in order to determine the pseudo-earthquake excitations in the earthquake response analysis of structures.

In this paper, a procedure for obtaining the pseudo-earthquake ground motions characterized as a stochastic process is shown. At first, the spectral characteristics of pseudo-earthquake ground motions are estimated on the basis of the spectral aspects of several seismograms recorded at the construction site and the results of ground oscillation tests by means of a blast of explosives and a vibration exciter. By smoothing these characteristics from the engineering of view, the spectral characteriscs of the pseudo-earthquake excitations are given by the mean velocity amplitude spctrum defined in the frequency range relevant to the expected frequency range of the structure considered. The duration of excitation is supposed to be thirty seconds and the above-mentioned spectral characteristics are approximately simulated by making use of the linear transfer function represented by the rational function and a band-limied white noise. Classifying by the frquency band width, four pour pseudo-earthquake ensembles, each of which consists of seven members, generated by means of an analog computer and a noise generator.

For the purpose of examining the spectral characteristics of pseudo-earthquake groud motions obtained in the above, the spectral densities of the band-limited white noise and those of the pseudo-earthquake velocity and accelaration are evaluated as the Fourier transforms of the corresponding auto-correlation fuuctions by using a digital computer. It is found that the ensemble average of the spectral densities of the seven pseudo-earthquakes coincides satisfactorily with the spectral characteristics prescribed at the construction site.

Characteristics of Pseudo-Earthquake Ground Motion (Part 2)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE, Yoshihiro TAKEUCHI and Masahiro KAWANO

Transactions of the Architectural Institute of Japan, Extra, Oct., 1967, p. 162 (in Japanese).

Abstract

The artificial earthquakes desirable for structural response analysis as the input data of earthquake excitations are generated from the output of a band limited white noise generator by means of an electronic analog computer. The spectral characteristics of the artificial earthquakes are prescribed by considering the vibrational ground characteristics. Several ensembles of artificial earthquakes corresponding to several kinds of spectral characteristics are proposed here. Each earthquake excitation has a time duration of thirty seconds and an envelope represented by a step function.

The maximum relative displacements of a one-mass system subjected to such earthquake excitations are computed with the variation of the natural period and the damping ratio of the system. Average response spsctra represented by the ensemble averages of the maxima of pseudovelocity, so called Sv, are shown graphically. The average response spectra are greatly affected by a configuration of the spectral characteristics of the artificial earthquake excitation. Although the variation with the frequency of the average response spectra is a complicated one in the case of no damping, the damped average response spectra are shown as smoothed curves and similar to each other, but their ordinate is nearly inversely proportional to the square root of the damping ratio.

As for the frequency distribution of the time when the maximum response occurred, there is a strong probabilty that the response of the system without damping would reach its maximum value at the end of the earthquake excitation, while the damped system under consideration may yield the maximum response at any time during the earthquake excitation except for part of the beginning.

The value of the damping ratio of the system has a great effect on the probability distribution in the ensemble of the maximum response. The distribution in the case of the system without damping seems to be a dispersed one. That of the damped system, however, has a remarkable peak at average value, and the larger the damping ratio, the higher the peak becomes.

Stiffness and Damping Characteristics of an Elastic Ground-Foundation System

By Takuji KOBORI, Ryoichiro MINAI and Tamotsu SUZUKI

Transactions of the Architectural Institute of Japan, Extra, Oct., 1967, p. 165 (in Japanese).

Abstract

As to a general expression of the dynamical characteristics of sub-soil ground, we have already discussed the "Dynamical Ground Compliance" of a rectangular foundation on a semi-infinite elastic medium and on an elastic stratum over a semi-infinite rigid medium. This is expressed by the ratio of the displacement of a foundation to a harmonic disturbing force in the same direction, corresponding to a transfer function of the gronud-foundation system.

In this paper, the Dynamical Ground Compliance of such a system calculated in the previous papers is approximately replaced by the dynamical characteristics of the well-known foundation system. In this system a foundation is sustained by the visco-elastic element that is a parallel combination of a spring and a dashpot. Then we can obtain the equivalent spring and viscous damping coefficient of this replaced system as a function of frequency.

Results are summarized as follows:

(1) We can find out a notable difference in comparison with the case of a semi-infinite medium. That is, there are three kinds of innumerable resonant frequencies in the case of a stratified medium. As the elastic stratum is assumed to be a non-dissipative medium and also no waves can propagate from the stratum to a rigid base, so the resonant amplitude becomes infinite. Then the equivalent coefficients vanish at their resonant frequencies.

(2) Because of the energy diffusion caused by the wave propagation, the ground has an apparent attenuating effect. In the case of a stratifed medium, this effect is extremely small or else non-existent in the frequency range below the lowest resonant frequency. In the case of a semi-infinite medium, on the other hand, its effect grows with the increase of the frequency for the rotational excitation and also seems to be almost constant in the frequency range calculated here for the vertical and horizontal excitaions.

(3) The equivalent stiffness characteristic is, as a whole, a gradually decreasing function of frequency. As the rigid half-space restricts the displacement of the elastic stratum, it is pointed out, especially in the range of low frequency, that the smaller the ratio of the depth of a stratum to the width of a foundation becomes, the larger stiffness characteristic has the ground, and also that it is larger in the case of a welded contact than that of a smooth contact between the two media.

Optimum Distribution of Shear Strength for Aseismic Design of Tall Elastic Building Structures

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE and Toshiharu HISATOKU

Transactions of the Architectural Institute of Japan, Oct., 1967, p. 186
(in Japanese).

Abstract

For the purpose of obtaining the aseismic design data of tall elastic building structures with a comparatively long fundamental natural period from 1 to 5 seconds, the earthquake responses of the seven-degree-of-freedom, linear, shear type vibrational system are analyzed by means of the root squared sum modal analysis. As the excitation patterns five typical different wave-shape functions of past earthquakes, namely. EL CENTRO NS, EL CENTRO EW, VERNON S82°E, TAFT EW, and OSAKA 205 EW are considered. For convenience of analysis, the distributions of the dynamic characteristics of structural models are assumed as follow; the mass distribution is uniform over the height, the stiffness distribution is characterized by a set of two structural constants A and B, in the form $\{\kappa_i\}=\{1-A((i-1)/(n-1))^B\}$, and the critical damping ratio of the fundamental harmonics is 0.02. In this paper, the optimum distribution of dynamic characteristics of the structural model is discussed mainly on the basis of the distribution of shear strength at elastic limit, which gives the reasonable distribution of the maximum ductility factor from the standpoint of earthquake engineering.

The main remarks obtained in this elastic analysis are as follows:

I The distribution of the maximum relative displacement is strongly affected not only by the stiffness distribution, but also by the natural period of structure and the wave-shape function of earthquake excitation.

II If the natural period of structure and the wave-shape function of earthquake excitation are given the optimum distribution of shear strength at elastic limit, which makes the distribution of the maximum ductility factor agree with the prescribed distribution of allowable ductility factor, it is determined almost independent of the stiffness distribution. In additon, if the uniform distribution of the maximum relative displacement is desired, the stiffness distribution which realizes this condition can be uniquely determined.

III The optimum distribution of shear strength at elastic limit for design use may be given by the average distribution of weighted shear force responses for the appropriate group of earthquake excitations. It is noted that the distribution of the maximum ductility factor of the structure designed by this distribution of shear strength will show some deviation from the prescribed distribution of the allowable ductility factor.

Response Characteristics of a Structure and Ground to the Matsushiro Earthquakes (No. 1 and No. 2)

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE, Yoshihiro TAKEUCHI and Teruo KAMADA

Transactions of the Architectural Institute of Japan, Extra, Oct., 1967, pp. 216-217 (in Japanese).

Abstract

For the purpose of making a study of the earthquake response of the coupled ground-structure system, observation of the Matsushiro earthquakes was carried out at Matsushiro High School, which is in the earthquake swarm area. A two storey reinforced concrete school building on a soft clay stratum was selected as an object of observaion. Earthquake responses of the structure and ground measured at each floor level, at the ground surface and under the ground were recorded on magnetic tape. Analyses of this valuable data are now under way and the results of the analyses will be useful information about the idealization of earthquake excitations and of the ground-structure system in the dynamic analysis of the aseismic design of structures.

According to the results of the boring test, the ground consists of very soft clay and there is a thin gravel layer at about 20 m deep under the ground surface. General discussions of the earthquake responses of the structure and ground have already been made in other papers, so the vibrational characteristics of the ground are mainly described in part 1 of this report based on the analyses of earthquake records obtained under ground. From the ratio of power spectral densities obtained under ground. From the ratio of power spectral densities of underground earthquake records, the transfer characteristics of seismic waves in the surface layer are considred. It is indicated that although there exists no remarkable difference between two records at 10 m and 20 m deep under the ground surface, the power in the low frequency range below 5 cps. becomes larger in the response of ground near the surface.

In part 2, the earthquake response of the structure is considered. Relative displacements between each floor are obviously found during the main shocks, however, the translational motion as a rigid body is dominant during earthquake motions. The spectral characteristics of responses of the ground-structure system are estimated based upon the so-called velocity response spectra which are evaluated by using an electronic analog computer. The average velocity response spectra for three different earthquakes show that the maximum value may occur in the neighbourhood of 11 cps. which is the dominant frequency of the main shocks. It is also found that the structural system has the effect of decreasing the high frequency component and increasing the low frequency component which are contained in seismic waves, and that the fundamental natural frequency of the coupled ground-structure system is about 4 cps.

Elastic Waves in a Liquid-Saturated Porous Solid

By Takuji KOBORI, Ryoichiro MINAI, Tamotsu SUZUKI, Kaoru KUSAKABE and Tsuyoshi TACHIKAWA

Transactions of the Architectural Institute of Japan, Extra, Oct., 1967, p. 226 (in Japanese).

Abstract

It is very important to study the effect of the dynamic characteristics of soil-ground on the earthquake response of structures, particularly for structures on soft clay or loose sand saturated with water. As the first step of this study the properties of elastic waves in such a soil-ground should be found by supposing a pertinent mathematical model of the actual fluid-saturated porous soil-ground. In this paper, based upon the elastic wave propagation theory of a fluid-saturated porous solid presented by M. A. Biot and developed by H. Deresiewicz, the dependence of velocities of bodily waves and Rayleighw aves on the elastic constants and the porosity of a compressible liquid-saturated porous solid is numerically analyzed and the reflection characteristics of elastic waves at the free surface are also studied.

First, the pertinent relations between elastic or physical constants, which concern the composite solid consisting of an elastic skeleton and compressible liquid, and porosity, which represents the amount of liquid in the composite solid, are formulated. Then, by supposing the appropriate values of the elastic and physical constants, the velocities of the two kinds of dilatational waves and of the distortional waves in the liquid-saturated porous elastic solid are calculated. As a result, it is found that both velocities of the two dilatational waves are increasing functions of porosity and also that one of them increases from the velocity of the dilatational waves of the skeleton to the velocity of the compressional waves of the liquid, and the other approaches exponentially to the velocity of the dilatational waves of the skeleton as porosity is varied from zero to unity.

Next, the velocity of Rayleigh waves in the infinife half-space with the free surface in analyzed in the two cases of a pervious boundary and of an impervious boundary. It is found that only one velocity of Rayleigh waves exists in each case and that the velocity of Rayleigh waves in the liquid-saturated porous solid is slightly smaller than that in the corresponding purely elastic solid.

Finally, reflection characteristics of the dilatational waves incident upon the pervious free boundary are estimated. The amplitude ratios and the energy flux ratios between the three kinds of reflected waves and the incident dilatational waves are calculated while the angle of incidence is continuously varied. As a result, it is found that even for comparatively slight porosity, the reflection characteristics in the liquid-saturated porous solid are considerably different from those in the pure elastic solid, for instance, the rate of the reflected distortional waves due to incident dilatational waves is fairly low for the liquid-saturated porous elastic solid compared to the case of the purely elastic solid.

On the Observation of the Earthquake Response of a Reinforced Concrete Building and Its Neighbouring Ground, Parts 3 and 4

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE, Yoshihiro TAKEUCHI and Teruo KAMADA

Proceedings of the 4th Japan National Congress for Natural Disaster Science, Oct., 1967, pp. 164-169 (in Japanese).

Abstract

The earthquake responses of a two-story, reinforced concrete structure and of the ground near the structure caused by the Matsushiro Earthquake Swarm are observed simultaneously on each floor of the structure and on the neighbouring ground or under the ground near the structure by using bore holes.

In Part Three of this report, the spectral characteristics of ground motions are mainly discussed through analysis of the power spectral density, and also the coupling effect of the structure on the ground is considered. In Part Four of this report, the spectral characteristics of the response of the structure are mainly discussed from these spectral analysis and the dynamic properties of the coupled ground structure system are considered.

Several obvious remarks can be made as follows:

(1) The spectral characteristics of two horizontal components of ground motions perpendicular to each other at about twenty meters under the ground are similar together as well as on the ground near the structure. However, the spectral density of the motion on the ground about three meters away from the structure is predominant at the frequency range of two to five cycles per second, while that under the ground has a remarkable peak at seven or eight cycles per second.

(2) By comparison of the two vertical components of ground motions at the above-mentioned locations, spectral characteristics of vertical motions near the ground surface scarcely seem to vary except the frequency range lower than three cycles per second.

(3) The responses observed on each floor of the structure seem to show the rocking motion of a rigid structure on soft ground and the natural frequency of the lowest rocking vibration mode is estimated to be about four cycles per second.

(4) The coupled ground-structure system may have other natural frequencies corresponding to higher modes of vibration at about eight, eleven and sixteen cycles per second.

(5) The coupling effect of the structure on the ground may be negligible if the distance away from the structure is more than thirty meters and if the depth from the ground surface is more than ten meters.

On the Optimum Dynamic Characteristics of Tall Elastic Building Structures for Earthquake Excitations

By Takuji KOBORI, Ryoichiro MINAI, Yutaka INOUE and Toshiharu HISATOKU

Proceedings of the 4th Japan National Congress for Natural Disaster Science, Oct., 1967, pp. 170-173 (in Japanese).

Abstract

For the purpose of obtaining the aseismic design data of tall building structures by which the optimum dynamic characteristics are assigned to the structural frames, based upon conventional static design procedure, the earthquake responses of a large number of linear structural models having various stiffness characteristics are systematically analyzed by means of the so-called modal analysis.

The stiffness distribution of the dynamical models considered here is expressed in the form, $\{\kappa_i\}=\{1-A((i-1)/(n-1))^B\}$ where A and B are the structural constants related to the stiffness distribution, i and n denote the number of mass and of the degree-of-freedom of the structural model, respectively. The stiffness vector of the structure is given by the product of the above-mentioned stiffness distribution and the reference stiffness which can be selected to provide the arbitrarily prescribed fundamental period of structure. On the other hand, the mass distribution is supposed to be uniform over the height. It is also assumed that the damping distribution is identical to the stiffness distribution and that the structure has 2% critical damping with respect to the fundamental harmonics. As regards earthquake excitations five typical wave-shape functions of strong earthquakes in the past are considered and the time-constant represented by the duration time is varied.

The optimum distribution of shear strength at elastic limit is determined so that the distribution of the maximum ductility factor is uniform over the height. On the other hand, the optimum reference value of shear strength is considered on the basis of the base shear coefficient which gives unit maximum ductility factor at the lowest story for the maximum amplitude of ground acceleration, 0.1 g.

The main results obtained are as follows:

I. While the optimum distribution of shear strength at elastic limit is strongly dependent on mass distribution, it is almost independent of stiffness distribution. Moreover, it is hardly affected by the fundamental period of structure and the wave-shape of earthquake excitation.

II. The optimum distribution of shear strength for practical use is obtained by averaging the distributions of shearing force responses of an elastic structure to various earthquake excitations having appropriate wave-shape functions and time-constants. For this optimum distribution of shear strength, it is necessary to expect a certain amount of deviation from the uniform distribution of the maximum ductility factor.

III. The average value of the maximum relative displacement over the height scarcely depends on the structural constants of the stiffness distribution but is affected mainly by the ratio of the fundamental period to the time-constant of excitation as well as the maximum value and wave-shape function of earthquake excitation. The same feature is valid for the base shear coefficient.

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